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# *Handbook of Illinois Stratigraphy*

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# *HANDBOOK OF ILLINOIS STRATIGRAPHY*

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## *ABSTRACT*

This handbook describes briefly the 730 stratigraphic units that are named in Illinois. It contains references to original and more recent descriptions, charts showing the development of the stratigraphic classifications, and maps indicating the distribution, thickness, and structure of many units.

Precambrian rocks are not exposed in Illinois and have been encountered in only a few deep borings. However, Paleozoic rocks as much as 14,000 feet thick occur in Illinois, and all Paleozoic systems except the Permian are represented and well exposed. The type region of the Mississippian System is along the Mississippi Valley in Illinois, Iowa, and Missouri. The Mesozoic Era is represented in Illinois only by the Cretaceous System, which is present in the Mississippi Embayment area in extreme southern Illinois and locally in western Illinois. Both the Tertiary and Quaternary Systems of the Cenozoic Era are represented. Tertiary rocks occur in southern Illinois and in small, widely separated patches elsewhere; Quaternary rocks, which include the Pleistocene glacial deposits, are found almost everywhere in the state.

## *INTRODUCTION*

Although it is regarded as a flat prairie state, the boundaries of three-fourths of Illinois are the deep valleys of the Mississippi, Ohio, and Wabash Rivers. These rivers and their tributaries have deeply entrenched themselves into the prairie, in many places exposing a variety of rock formations in the steep valley slopes. With the exception of intrusive igneous rocks in extreme southern Illinois, the exposed rocks are all sedimentary.

The branch of geology that describes the sequence of the layered rocks is called stratigraphy. It enables geologists and others to determine the position of a rock exposure (or of a sample from a boring) in the sequence, thus in effect establishing the age of the rock. The order, distribution, and composition of the rocks in Illinois have been studied since the days of the early settlers. After nearly 150 years of investigations, some 730 stratigraphic

ERA, ERATHM	PERIOD, SYSTEM	EPOCH, SERIES	ORIGIN AND CHARACTER	GREATEST THICKNESS (ft) <sup>1</sup>	AGE (millions of years) <sup>2</sup>		
CENOZOIC	QUATERNARY	PLEISTOCENE	Continental—glacial, river and stream, wind, lake, swamp, and alluvial deposits and soils	600	1.5		
	TERTIARY	PLIOCENE	Continental — river deposits, mostly gravel, some sand	50		7	
		EOCENE	Deltaic — mostly sand, same silt	300	64-65		
		PALEOCENE	Marine — mostly clay, same sand	150		{ 125 <sup>3</sup> 136 <sup>4</sup> 225 <sup>5</sup> 280 <sup>6</sup>	
		MESOZOIC	CRETACEOUS	GULFIAN	Deltaic and nearshore marine — sand, same silt and clay, locally lignitic		500
	PALEOZOIC	PENNSYLVANIAN	VIRGILIAN	Marine, deltaic, continental — cyclical deposits, mostly shale, sandstone, and siltstone with some limestone, coal, clay, black sheety shale; sandstone dominant in lower part, shale above; coal most prominent in middle part, limestone in upper part	3000	345	
MISSOURIAN							
DESMOINESIAN							
ATOKAN							
MORROWAN							
MISSISSIPPIAN		CHESTERIAN	Marine, deltaic — cyclical deposits of limestone, sandstone, shale	1400	395		
		VALMEYERAN	Marine, deltaic — limestone, siltstone, shale, chert, sandstone	2000		430-440	
		KINDERHOOKIAN	Marine — shale, limestone, siltstone	150			500
		DEVONIAN	UPPER	Marine — shale, limestone			
MIDDLE			Marine — largely limestone, some shale	450			
			LOWER	Marine — cherty limestone, chert	1300		
SILURIAN		CAYUGAN	Marine — shale, siltstone, limestone	100	500		
		NIAGARAN	Marine — dolomite, limestone, shale, local reefs	1000			
		ALEXANDRIAN	Marine — dolomite, limestone, shale	150			
ORDOVICIAN	CINCINNATIAN	Marine — shale, limestone, siltstone, dolomite	300	500			
	CHAMPLAINIAN	Marine — limestone, dolomite, sandstone	1400				
	CANADIAN	Marine — dolomite, sandstone	1000				
CAMBRIAN	CROIXAN	Marine — sandstone, dolomite, shale	4000				
PRECAMBRIAN			Intrusive igneous rocks — mostly granite				

<sup>1</sup> Greatest thickness in one locality.<sup>2</sup> Radiometric age of beginning of interval.  
(After Harland [1964] and others. Estimates from chart by Van Eysinga [1972].)<sup>3</sup> Beginning of Gulfian (est.).<sup>4</sup> Beginning of Cretaceous.<sup>5</sup> Beginning of Mesozoic.<sup>6</sup> End of Pennsylvanian.<sup>7</sup> Beginning of Pennsylvanian (est.).<sup>8</sup> Beginning of Croixan (est.).<sup>9</sup> Beginning of Cambrian.

Fig. 1—Summary of the age, origin, and thickness of Illinois rocks.

names are currently used in Illinois. Most of these units have been named in the past 50 years, and more will be named in future studies. However, no new stratigraphic names are introduced in this handbook.

The handbook is designed as a guide to the stratigraphic classification of the rocks of Illinois. It includes brief descriptions of all units now recognized by the Illinois State Geological Survey, as well as references to more extensive descriptions in other publications. More complete lists of references to these units and to the many abandoned stratigraphic names encountered in the literature can be found in Illinois State Geological Survey Bulletin 92, *Bibliography and Index of Illinois Geology Through 1965*.

Knowledge of the stratigraphic sequence of the rocks of Illinois (fig. 1) has been of great value in the search for and the development of the mineral resources of the state. Many of the rock formations have been the source of the limestone, dolomite, gravel, sand, and clay used in highway and building construction and for industrial and agricultural purposes. Illinois formations have produced, and still contain, large resources of coal and oil, as well as important but more limited resources of fluor spar, zinc, lead, and other minerals. They are also a major source of water.

In recent years, the requirements of a rapidly expanding population have brought about the general realization that mineral resources are exhaustible. The wise use and care of the air, sea, and land, and the rocks that underlie them have become necessary to assure a favorable environment and to prolong the availability of the raw materials needed for modern life.

### *The Stratigraphers*

The foundations of stratigraphic geology in Illinois go back to the 1830s when the state contained only about 200,000 people, most of them settled along the major valleys in the southern half of the state. Modern geological literature seldom acknowledges the geologists of that time, who on foot, by boat, and later by horse and buggy, explored unknown and often dangerous areas. Their contributions are briefly summarized here, along with those of noted geologists active before the 1930s (fig. 2).

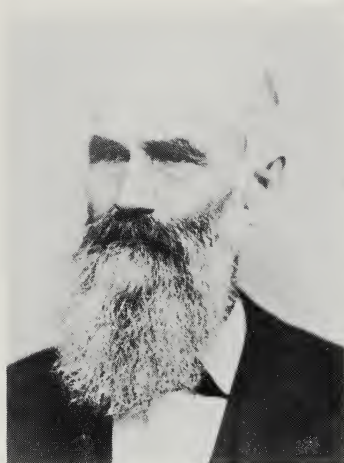
The observations of the early travelers largely concerned minerals, soils, and topography, but H. R. Schoolcraft (1825) and C. U. Shepard (1838) described some strati-

graphic features (White and Slanker, 1962; White, 1969). One of the first to make significant observations about the nature, sequence, and ages of the rocks of Illinois was David Dale Owen, a geologist from New Harmony, Indiana, who in the late 1830s was commissioned by the Federal Government to explore the geology of parts of Iowa, Wisconsin, and Illinois. He correctly identified the ages of many formations exposed along the Ohio and Mississippi Rivers.

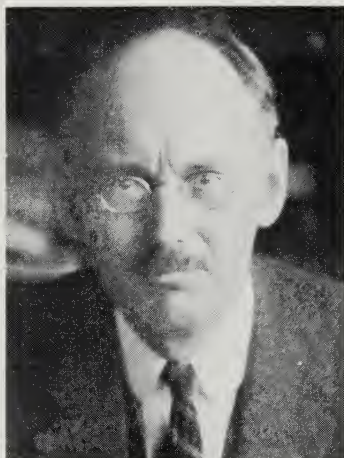
In the 1840s, James Hall of the New York State Geological Survey correlated, largely on the basis of fossils, many of the rock units in the Mississippi Valley with the New York section, which had become the American standard reference section. Hall prepared a geologic map (fig. 3), which, in spite of scanty information, brought out some of the prominent features of the bedrock geology of Illinois, including the basin-like configuration of the rock formations.

In 1851 the Illinois State Legislature authorized a geological survey of the state, and J. G. Norwood was appointed the first State Geologist of Illinois. No official reports were published during Norwood's tenure (1851 to 1858), although he published several papers on Carboniferous fossils. The geology of the state was still largely unknown in 1858 when A. H. Worthen was appointed Director of the Geological Survey of Illinois. Worthen and his associates—H. M. Bannister, F. H. Bradley, G. C. Broadhead, E. T. Cox, Henry Engelman, H. C. Freeman, H. A. Green, and James Shaw—surveyed the entire state and, between 1866 and 1875, published reports on every county except De Witt in five large volumes (fig. 4). They discovered and traced throughout the state, with remarkably few errors, nearly all the major units now recognized. These five volumes and an additional three volumes contain descriptions of numerous fossils, many of them new species, by Worthen and leading paleontologists of the day—Leo Lesquereux on plants, F. B. Meek and S. A. Miller on invertebrates, J. S. Newberry on vertebrates, Orestes St. John on fishes, S. H. Scudder on insects, E. O. Ulrich on bryozoans, and Charles Wachsmuth and Frank Springer on crinoids and blastoids.

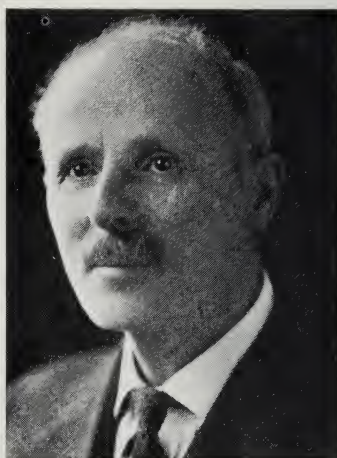
Worthen's 1875 geologic map of Illinois (fig. 5) showed how enormously knowledge of the stratigraphy of Illinois had expanded in the 32 years since Hall's map. Later geologic maps (Stuart Weller, 1906a, 1907; DeWolf et al., 1917; J. Marvin Weller et al., 1945; and Willman et al., 1967) have added many details (figs. 6, 10) but have not greatly altered



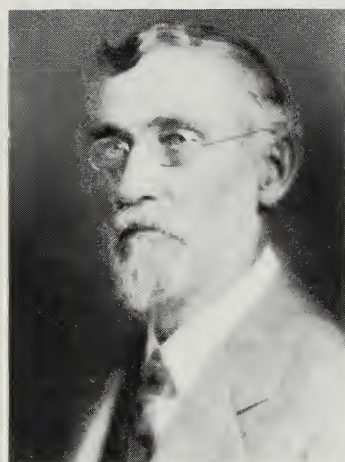
Amos H. Worthen  
1813-1888



Stuart Weller  
1871-1927



Thomas E. Savage  
1866-1947



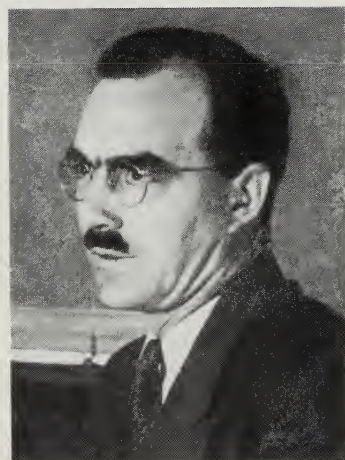
Frank Leverett  
1859-1943



Gilbert H. Cady  
1882-1970



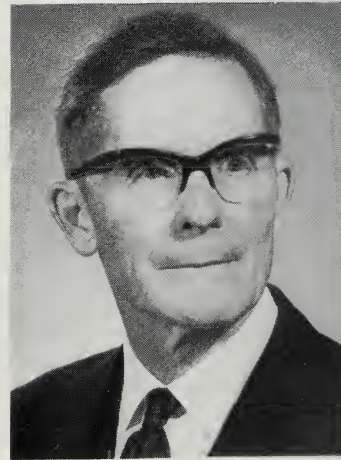
Morris M. Leighton  
1887-1971



J. Marvin Weller  
1899-



Harold R. Wanless  
1898-1970



Lewis E. Workman  
1899-

Fig. 2—Major contributors to the stratigraphy of Illinois.



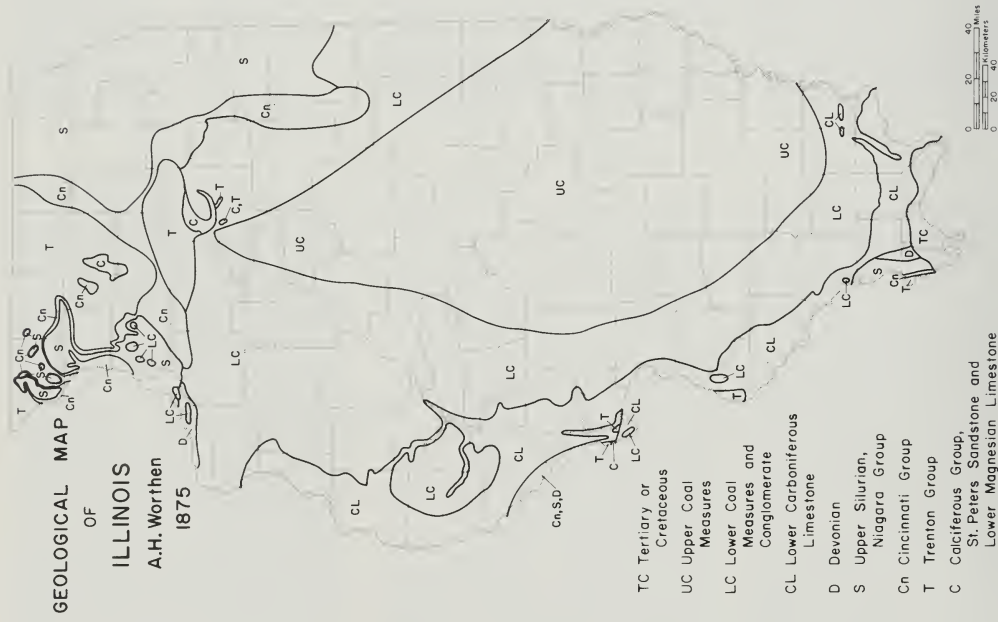


Fig. 5—Geologic map of Illinois by A. H. Worthen (1875).



Fig. 6—Geologic map of Illinois by Stuart Weller (1907).

who was later named chief. Among the outstanding geologists who worked for the Survey were G. H. Cady, whose studies for nearly 50 years were mainly of Pennsylvanian stratigraphy; T. E. Savage, an authority on Silurian stratigraphy who also contributed to Ordovician, Pennsylvanian, and Pleistocene stratigraphy; and Stuart Weller, who is best known for his studies of the Mississippian System but who also contributed to the Silurian and Devonian stratigraphy. Weller's geologic maps of Illinois in 1906 and 1907 (fig. 6) refined and added many details to the previous maps.

Before 1920, many geologists whose major interests were elsewhere made contributions to Illinois stratigraphy, including W. C. Alden, H. F. Bain, H. H. Barrows, R. S. Blatchley, Charles Butts, J. E. Carman, G. H. Cox, N. M. Fenneman, J. W. Goldthwait, O. H. Hershey, Henry Hinds, F. H. Kay, C. R. Keyes, R. D. Salisbury, E. W. Shaw, A. C. Trowbridge, Jon A. Udden, and E. O. Ulrich.

In the 1920s, studies of the Pleistocene were expanded under the direction of M. M. Leighton, who became Chief of the Illinois State Geological Survey in 1923. Leighton made many contributions to the classification of the glacial deposits and to knowledge of the buried soils. Associated with him during this time were F. C. Baker, J. H. Bretz, George E. Ekblaw, Paul MacClintock, and others.

J. Marvin Weller and H. R. Wanless widely traced many thin units of the Pennsylvanian rocks in the state, and they emphasized the cyclical nature of the sediments. G. H. Cady continued studies of Pennsylvanian stratigraphy in an expanded program in coal geology and paleontology. Studies by A. C. Noé added greatly to the knowledge of Pennsylvanian plants. Weller and A. H. Sutton continued the Mississippian studies initiated by Weller's father, Stuart Weller. J. E. Lamar and A. H. Sutton described the Cretaceous and Tertiary strata in southern Illinois, and Lamar made a detailed study of the St. Peter Sandstone. L. E. Workman directed an expanded program in subsurface studies that added much to the knowledge of the entire stratigraphic column.

Many details of the distribution and character of the formations were added by studies of areal and economic geology, particularly by L. F. Athy, J. R. Ball, C. F. Bassett, A. H. Bell, A. C. Bevan, J. H. Bretz, H. E. Culver, N. M. Fenneman, D. J. Fisher, R. S. Knapen, Frank Krey, J. E. Lamar, L. A. Mylius, J. N. Payne, W. W. Rubey, F. T. Thwaites, H. R. Wanless, and J. M. Weller.

Many of the above geologists continued stratigraphic studies after 1930, and they were joined by others who contributed significantly to Illinois stratigraphy. In addition to those still active in Illinois, the later stratigraphers included G. H. Emrich, G. O. Raasch, and J. S. Templeton (Cambrian); C. A. Bays, E. P. DuBois, A. M. Gutstadt, Paul Herbert, Jr., T. G. Perry, and Templeton (Ordovician); J. J. C. Ingels, H. A. Lowenstam, and C. A. Ross (Silurian); H. R. Schwalb and D. H. Swann (Devonian); G. V. Cohee, C. L. Cooper, C. G. Croneis, W. H. Easton, Tracey Gillette, C. B. Rexroad, A. J. Scott, Swann, and F. E. Tippie (Mississippian); K. E. Clegg, G. A. Desborough, C. O. Dunbar, L. G. Henbest, R. M. Kosanke, P. E. Potter, E. S. Richardson, Jr., J. M. Schopf, E. F. Taylor, and Raymond Siever (Pennsylvanian); Potter, W. A. Pryor, and Ross (Cretaceous-Tertiary); and J. A. Brophy, F. L. Doyle, H. E. Eveland, R. F. Flint, C. L. Horberg, W. E. Powers, P. R. Shaffer, F. L. Staplin, John Voss, and H. L. Wascher (Pleistocene).

The study of subsurface stratigraphy in Illinois received major impetus from the discovery of oil in the deeper parts of the Illinois Basin, from improved methods of geophysical logging, from extensive exploration for coal reserves, and from the search for geologic structures suitable for underground storage of natural gas. During these developments, many company geologists made contributions to Illinois stratigraphy.

### *Uses of Stratigraphy*

An understanding of the nature and stratigraphic relations of the rocks on which we live is fundamental to progress in the various fields of applied geology—in the search for and the development of mineral resources needed to support life (economic geology), in the solution of many construction and excavation problems (engineering geology), and in effective management of the environment (environmental geology).

Stratigraphy is used to direct exploration for most minerals, to evaluate recovery methods, and to expedite production. In engineering geology, knowledge of the sequence of rocks, their character, and their variations is needed for selecting suitable sites for foundations, dams, highways, tunnels, underground storage of gas and liquid petroleum products, waste disposal, and many other projects. In environmental geology, which in effect includes all the applications of geology related



Fig. 7—Physiographic divisions of Illinois (after Leighton et al., 1948).

TABLE 1—SOURCE ROCKS OF ILLINOIS MINERAL RESOURCES\*

Pleistocene	Gravel, common sand, peat, molding sand, clay products
Tertiary	Fuller's earth, gravel
Cretaceous	Gravel
Pennsylvanian	Coal, crude oil, gas, clay and shale products, stone, building stone, portland cement
Mississippian	Crude oil, gas, stone, clay and shale products, building stone, fluorspar, zinc, lead, lime, whiting, rock wool†
Devonian	Crude oil, gas, stone, tripoli, ganister†, novaculite gravel†
Silurian	Crude oil, gas, stone, building stone, lime, deadburned dolomite, rock wool†
Ordovician	Crude oil, gas, stone, silica sand, portland cement, building stone, zinc, lead, natural cement†
Cambrian	Stone

\*Ground water is produced from all systems.

†Not produced at present.

to man, stratigraphy is indispensable in regional planning, in effective use and preservation of mineral resources, in protection of water supplies, in selection of sites for waste disposal, and in many aspects of pollution control.

Illinois has abundant resources of the common rocks and minerals needed for building purposes, fuel for energy, water for domestic and industrial purposes, and soils for food production. Mineral resources that have been produced from the various systems of rocks are listed in table 1. Mineral production in Illinois in 1972, not including water, agricultural products, mineral products manufactured in Illinois, or mineral materials processed in Illinois, was valued at \$701,242,000, and nine

different mineral products had values exceeding \$1,000,000 (table 2). According to the U.S. Bureau of Mines, Illinois ranked eleventh in the nation in mineral production in 1972.

### Geographic Setting

Illinois overlooks the confluences of several great rivers—the Mississippi, Ohio, Missouri, Illinois, Tennessee, Cumberland, and Wabash. The state is about 380 miles long and 210 miles in maximum width, and it extends from the Great Lakes to the Gulf Coastal Plain.

More than three-fourths of Illinois is in the Till Plains Section of the Central Lowland Province (fig. 7). The Till Plains Section in Illinois is subdivided into seven areas. Four are largely in Illinoian drift (Rock River Hill Country, Galesburg Plain, Springfield Plain, Mt. Vernon Hill Country), but only locally do they have prominent glacial topography; they differ principally in the nature of their preglaciation surface. Two others (Green River Lowland, Kankakee Plain) are lowland areas, large parts of which are covered by sand dunes. The seventh area (Bloomington Ridged Plain) has prominent glacial topography characteristic of Wisconsinan glaciation. The deeply dissected Wisconsin Driftless Section, the glaciated Great Lakes Section, and a small area of the Dissected Till Plains Section also belong to the Central Lowland Province. The Great Lakes Section includes the strongly morainal area of Wisconsinan drift bordering Lake Michigan (Wheaton Morainal Country) and the plain that was covered by Lake Chicago (Chicago Lake Plain).

Small parts of the Lincoln Hills and the Salem Plateau Sections of the Ozark Plateaus Province, which are prominent in Missouri, extend into Illinois along the Mississippi River. These areas are both deeply dissected, but

TABLE 2—ILLINOIS MINERAL PRODUCTION IN 1972 (Malhotra, 1974)

Commodity	Quantity	Value (in thousands)
Coal	65,521,000 tons	\$402,301
Crude oil	34,874,000 bbl	121,013
Natural gas	1,194,000 MMcf	334
Natural gas liquids	168,000 bbl	566
Common clays	1,610,000 tons	2,652
Refractory clays	106,000 tons	662
Fluorspar	132,405 tons	9,961
Gravel	17,734,000 tons	23,367
Sand - construction	17,023,000 tons	19,109
Sand - industrial	5,173,000 tons	19,218
Crushed and broken stone	56,260,000 tons	94,225
Lead	1.335 tons	401
Zinc	11,378 tons	4,039
Others*		3,393
Total	\$701,242,000	

\* Including absorbent clays, dimension stone, tripoli, silver, peat, gem stones, and germanium, the values for which are withheld to avoid disclosing data from individual companies.



Fig. 8—Topography and rivers of Illinois.

the topography differs because the Lincoln Hills Section has flat-lying rocks and the Salem Plateau Section has faulted and warped strata.

The Shawnee Hills Section of the Interior Low Plateaus Province includes a rough-surfaced area with relatively high relief that is commonly referred to as the Illinois Ozarks. It is an unglaciated area in which much of the topography is controlled by the bedrock and local structures, including several faults and Hicks Dome.

Cache Valley, which was the Ancient Ohio Valley, sharply separates the Shawnee Hills from the Coastal Plain Province, the northern tip of which is in extreme southern Illinois. The Coastal Plain Province is characterized by rounded hills developed on relatively soft Cretaceous, Tertiary, and Pleistocene sediments.

Illinois has a total relief of about 950 feet, ranging from 285 feet above sea level at the junction of the Ohio and Mississippi Rivers in the southern tip of the state to 1235 feet above sea level at the top of Charles Mound in Jo Daviess County near the Wisconsin state line. However, more than half of Illinois is at an elevation between 600 and 800 feet above sea level (fig. 8).

The maximum local relief in Illinois is about 600 feet at Bald Knob, Cave Hill, and a few other localities in the Shawnee Hills of southern Illinois. Relief reaches 400 feet locally in the Driftless Area of northwestern Illinois, in Calhoun and Jersey Counties near the meeting of the Illinois and Mississippi Rivers, and at Peoria. About 200 feet of relief is common along the Mississippi River, along the Illinois River below La Salle, and at the front of the Bloomington Morainic System in northern Illinois. Outcrops of bedrock formations are abundant in all these areas, except along the Bloomington Morainic System.

The local relief is generally much less pronounced. Large areas of the Illinoian till plain are extremely flat—almost table-like—and many a square mile has less than 20 feet of relief. Most of the Wisconsinan till plain is distinguished by numerous rough-surfaced morainic ridges that are generally 50 to 100 feet high, a mile or two wide, and continuous for 50 to 100 miles. They are separated by intermorainic areas with more subdued, undulating topography, commonly described as “rolling” topography.

In some counties no exposures of the bedrock formations occur, and other counties have outcrops only in the larger valleys. In many areas exposures exist only as roadcuts,

quarries, and other man-made excavations. Consequently, the stratigraphic sequence in much of the state is determined almost entirely from subsurface data—principally from borings for water, oil, coal, and other minerals, and for waste disposal wells, underground storage of gas and liquid petroleum products, and sanitary systems. Logs of approximately 200,000 borings are on file at the Illinois State Geological Survey in Urbana. Many of these are geophysical logs. Sample cuttings from more than 58,000 borings and cores from more than 9000 borings also are filed at the Survey.

Illinois is divided into 102 counties. The counties and the township grid are shown in figure 9. The topography of the entire state has been mapped in 15-minute quadrangle units (scale: 1 inch = approximately 1 mile). About 50 percent of the state has been mapped topographically in 7.5-minute quadrangle units (scale: 2.5 inches = approximately 1 mile).

### *Geologic Setting*

The rocks of Illinois above the basement complex (the Precambrian rocks) are dominantly marine sediments deposited during the Paleozoic Era (fig. 1). They are the consolidated bedrock formations. The Cretaceous rocks of the Mesozoic Era, which are largely marine deltaic or nearshore sediments, are found only in relatively small areas in southern and western Illinois (fig. 10) and, except for a few thin units, are unconsolidated. Rocks of the Cenozoic Era include those forming at present and are the unconsolidated surficial rocks that directly underlie the surface of almost the entire state (fig. 11).

The Paleozoic rocks have a present maximum thickness of about 14,000 feet in the deep part of the Illinois Basin (fig. 12). Because the Paleozoic systems generally thicken southward into the deep part of the basin, the sum of the maximum thicknesses of the systems is not much greater, being only about 16,000 feet. However, because of unconformities and irregular deposition, the sum of the maximum thicknesses of the formational units in the state is much greater, about 25,000 feet. The Mesozoic rocks at their maximum are only about 500 feet thick. The Cenozoic rocks are as much as 600 feet thick but in most of the state are much thinner.

All the Paleozoic systems except the Permian are represented in Illinois. Rocks near Danville and La Salle once identified as Permian are now recognized as Pennsylvanian.

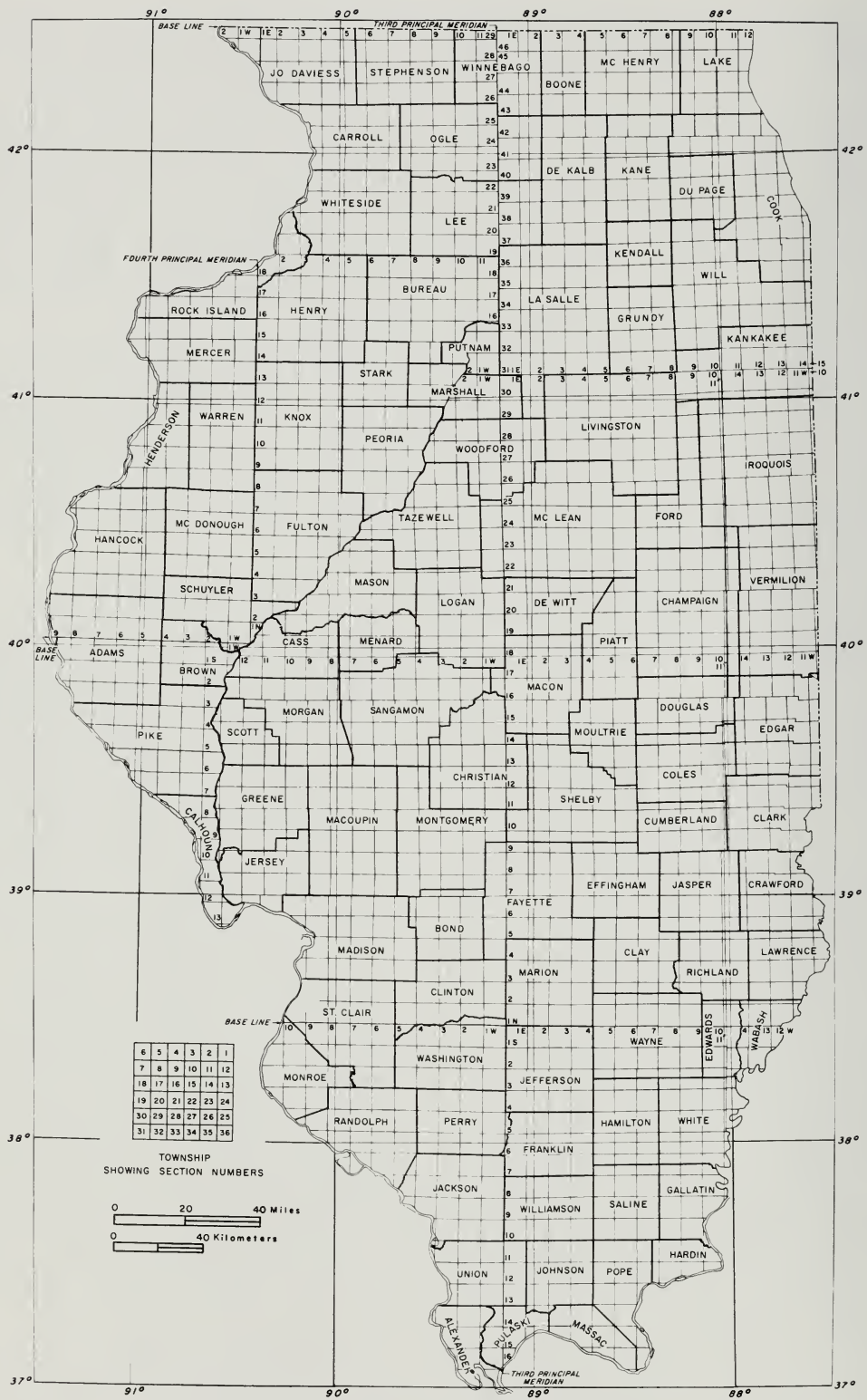
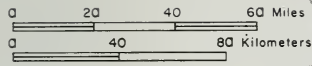


Fig. 9—Index map showing counties and townships.

## GEOLOGIC MAP



Pleistocene and  
Pliocene not shown

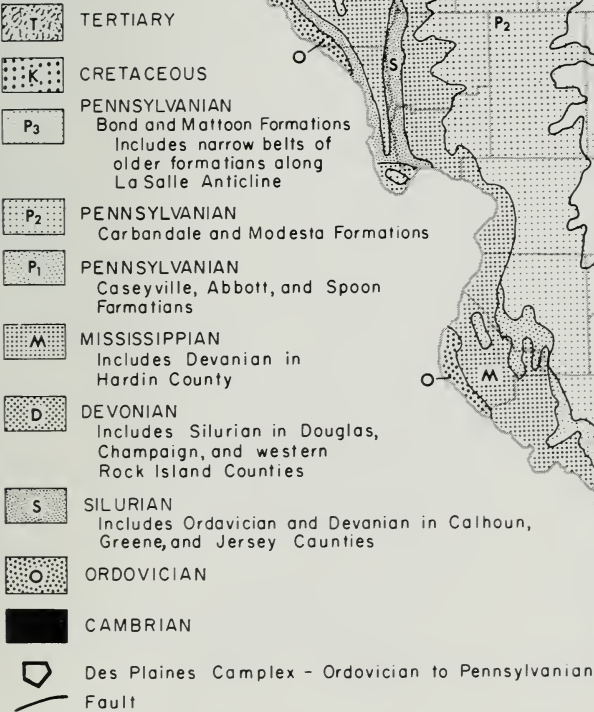
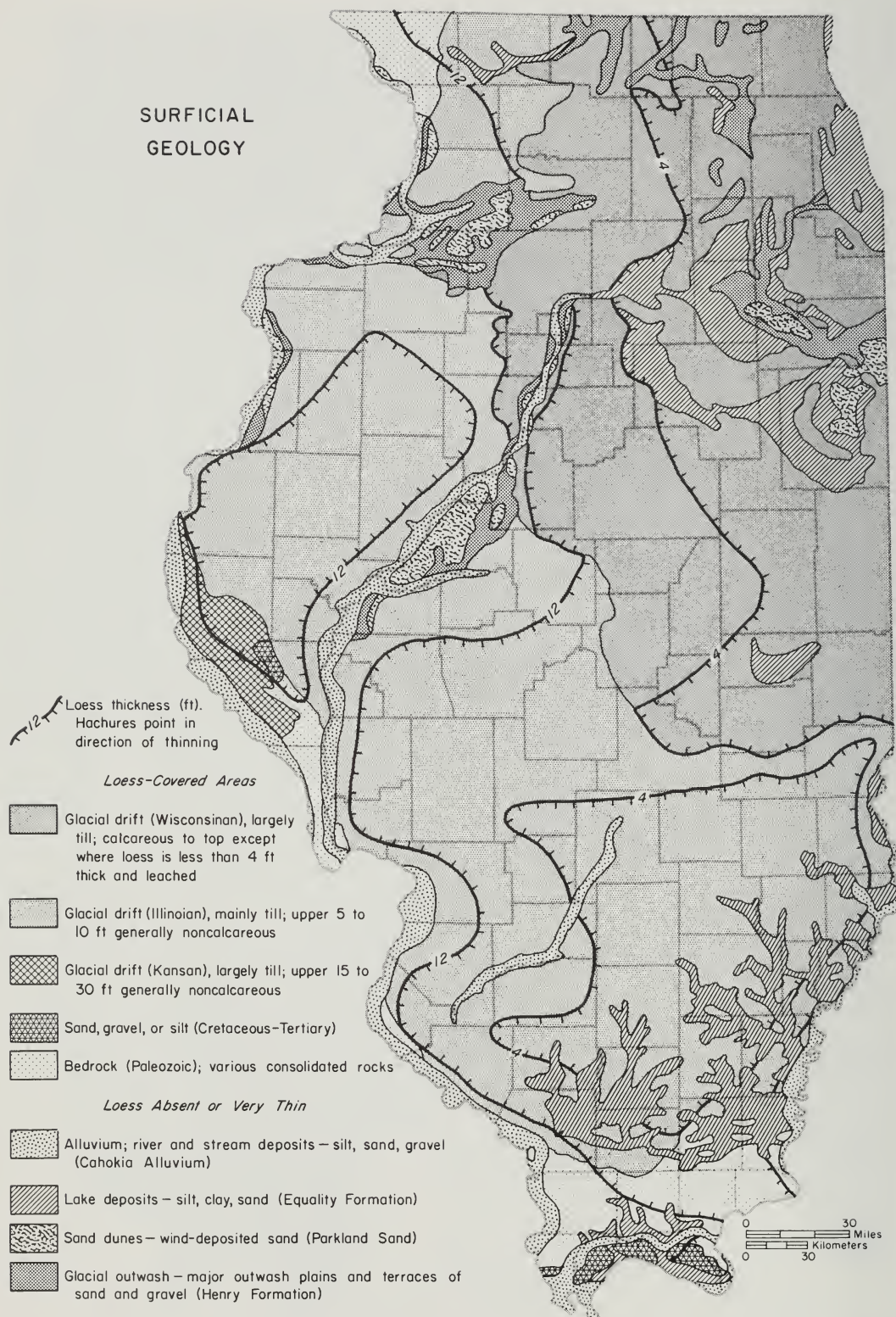


Fig. 10—Generalized areal geology of the bedrock surface (Willman and Frye, 1970).

# SURFICIAL GEOLOGY



**Fig. 11—Generalized surficial geology of Illinois. In uneroded areas the loess thins from 25-100 feet thick in the bluffs of the major valleys to 1-2 feet in areas farthest from the valleys.**

All the commonly recognized major subdivisions (series) of the Paleozoic systems except the lower and middle series of the Cambrian System are present in Illinois. The Mesozoic Era is poorly represented, as the Triassic and Jurassic Systems and the lower Cretaceous (Comanchean) Series are absent and the upper Cretaceous (Gulfian) rocks occur in only relatively small areas. The Cenozoic record is more complete, although the Tertiary System is confined largely to the southern margin of the state and the Oligocene and Miocene Series are not present. The areal distribution of the Paleozoic systems at the surface of the bedrock (fig. 10) is related to structure, unconformities, and the relief of the bedrock surface.

**Geologic Structure**—The structure of Illinois has been described as a spoon-shaped basin, called the Illinois Basin (fig. 12). It is oriented NNW to SSE, with the tip of the spoon in Kentucky and Tennessee and its eastern edge largely in Indiana. The deepest part of the basin is near or a little south of the mouth of the Wabash River, where Indiana, Kentucky, and Illinois meet. In the broadest definition, the Illinois Basin extends to the tops of the bordering positive areas, the major arches and uplifts, where the direction of the regional slopes is reversed. In this sense, essentially all of Illinois is within the basin, and the basin has a maximum depth of about 15,000 feet. However, the basin is defined by some as the much smaller area bounded by the -500-foot or -1000-foot contour on top of the Ottawa Megagroup (Trenton top), and by others as the area underlain by the Pennsylvanian rocks (the Eastern Interior Coal Basin).

The structure of the basin is not simple (figs. 12, 13). It is the product of a long history of repeated tectonic movements (Swann, 1968; Atherton, 1971). The major structure within the basin is the La Salle Anticlinal Belt, the western edge of which is a relatively steep monoclinical slope that faces west. Along it the strata in places decline as much as 2000-3000 feet on a slope as steep as 20 degrees. Faulting accounts for only a minor part of the relief in the La Salle Anticlinal Belt, although deep-seated faulting in Precambrian rocks may account for the deformation of the overlying sedimentary rocks. The deep part of the basin, from the southern end of the La Salle Anticlinal Belt to the similar but shorter, east-facing Du Quoin Monocline, is called the Fairfield Basin (fig. 12). Many smaller structures occur throughout the state.

The strata in the southern part of the basin are broken by a complex of faults (Weller et al., 1920; Stonehouse and Wilson, 1955; Baxter et al., 1963; Baxter and Desborough, 1965; Baxter et al., 1967). Some of them are thrust faults, such as the Shawneetown Fault, but most are normal faults, many of which bound grabens. A few faults have displacements of over 1000 feet, but most displacements are much smaller. Folds and faults also occur throughout the basin but, with a few exceptions, have gentle slopes and less than 200 feet of relief.

Perhaps the most intense deformation is in the Des Plaines and Glasford Disturbances (fig. 12), which are roughly circular crypto-explosion structures. Such structures were once interpreted as being volcanic in origin, but they are now believed to be astroblemes—structures produced by meteorite impact. Neither disturbance is exposed at the surface. The Des Plaines Disturbance (Emrich and Bergstrom, 1962; Buschbach and Heim, 1972) is buried by glacial drift. The Glasford Disturbance (Buschbach and Ryan, 1963) was formed in the Ordovician Period and buried by the youngest Ordovician and later Paleozoic rocks.

Hicks Dome (fig. 12), an even larger structure, lacks the intense deformation of the disturbances and is likely the result of a deep igneous intrusion. Igneous rocks (intrusive breccias, dikes, and sills) are present in the dome and in the surrounding areas (Baxter and Desborough, 1965). A few other domes in southern Illinois also may be related to igneous intrusion (English and Grogan, 1948). Numerous dikes and sills are encountered in coal mines and oil wells (Clegg and Bradbury, 1956). Other domal structures are related to the burial of Silurian reefs, many of which grew several hundred feet above the sea floor. Compaction and solution of rocks deposited around the rigid reefs resulted in the development of domal structures that continue hundreds of feet above the tops of the reefs.

The sinking of the Illinois Basin, relative to the surrounding positive areas, appears to have begun in Cambrian time, and it continued intermittently until the end of the Paleozoic Era, at least until after the end of the Pennsylvanian. During much of this time the basin appears to have been open to seas advancing from the south and at times from the west. During maximum invasions the seas spread over the entire basin and the surrounding positive areas. The differences between the structures of the several horizons mapped (figs. Pc-1, O-3, P-8), illustrate the progres-

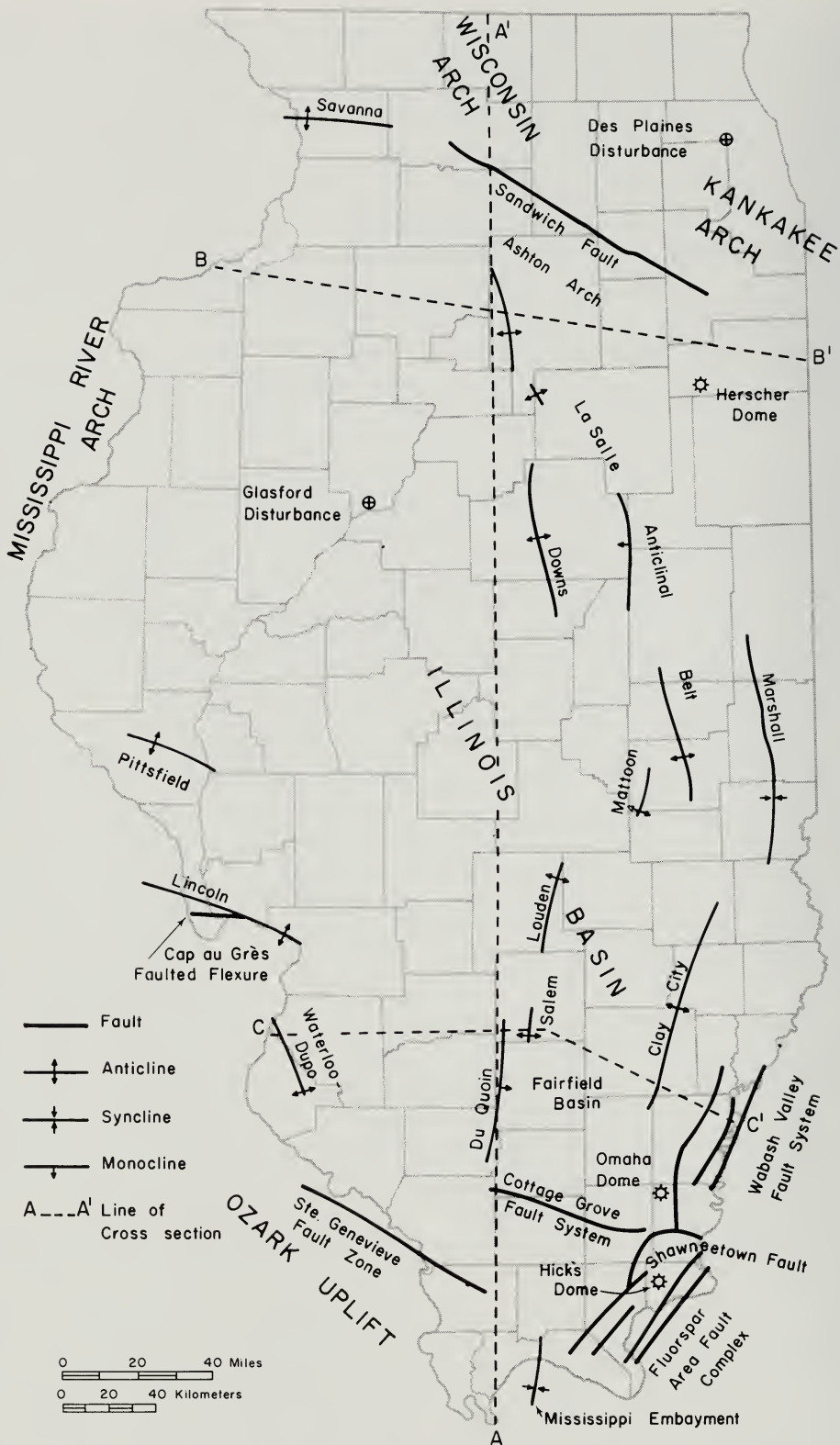


Fig. 12—Principal geologic structures of Illinois.

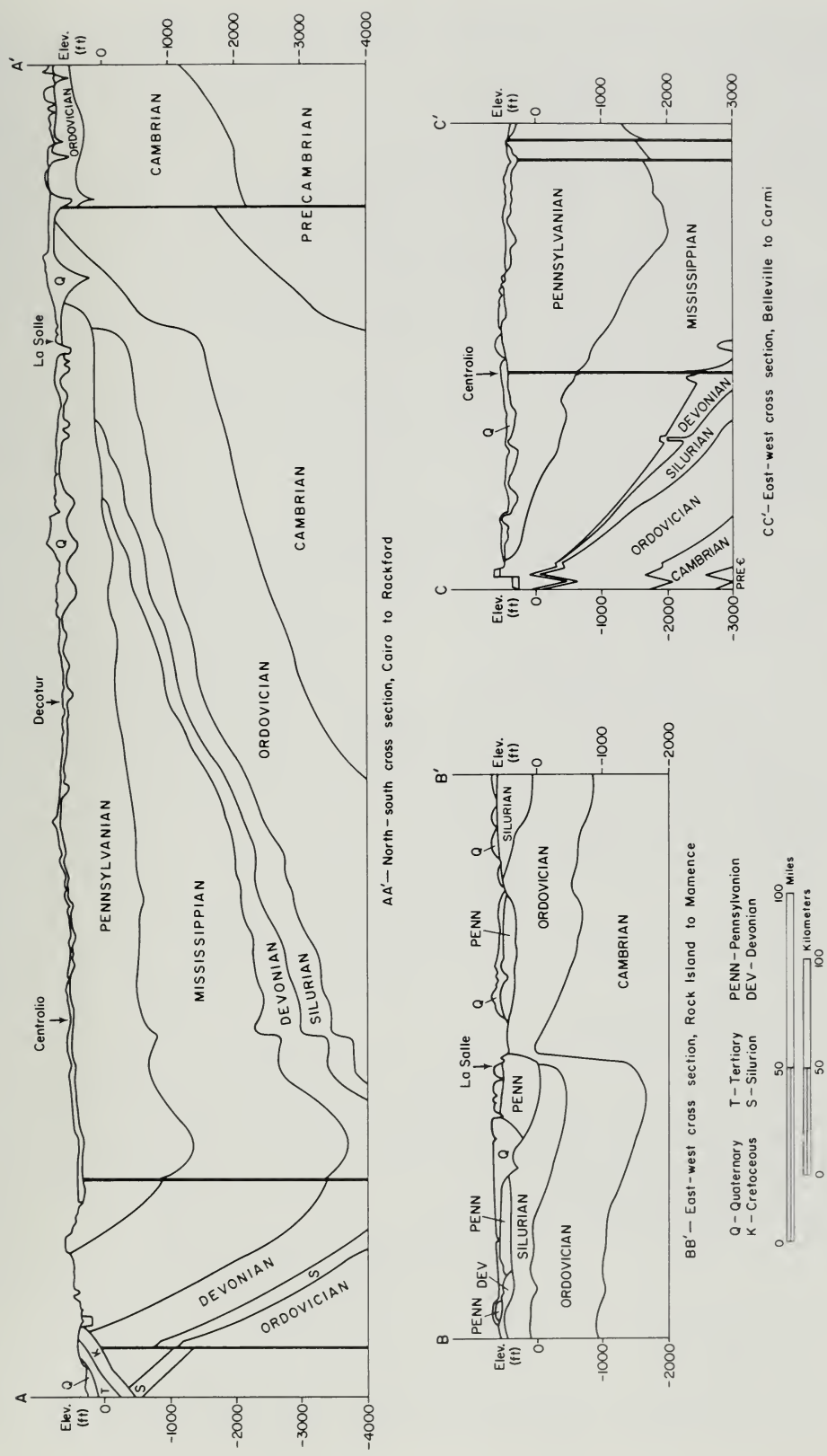


Fig. 13—Geologic cross sections along the lines shown in figure 12 (after Willman et al., 1967).

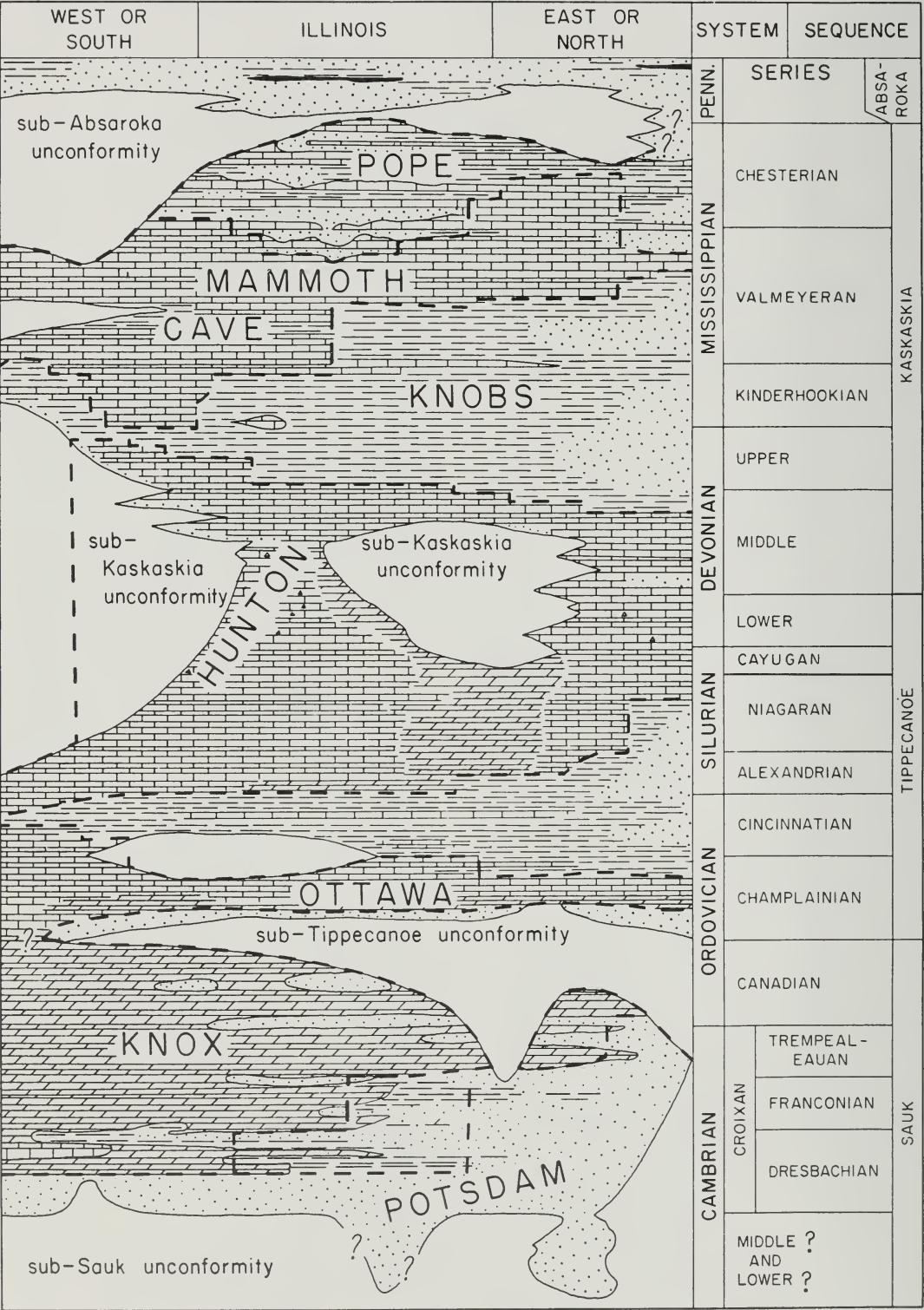


Fig. 14—Pre-Pennsylvanian megagroups and sequences of Illinois (Swann and Willman, 1961).

sive development of the basin. Tectonic movements resulted in the development of major unconformities during the intervals between each of the units mapped.

The absence of Permian, Triassic, Jurassic, and lower Cretaceous rocks prevents a close determination of the time when major tectonic movements ended in the Illinois Basin and when uplift of the east-west Pascola Arch south of Illinois in Kentucky and Missouri closed the Illinois Basin and gave it its present spoon-shaped configuration. However, the upper Cretaceous rocks of the Gulf Embayment area clearly overlap the intensely faulted area in southern Illinois, and only a few minor faults, possibly the result of slumping or solution-collapse, have been found cutting the Cretaceous, Tertiary, or the almost universally present Pleistocene rocks. Some local thickening of Cretaceous rocks along projections of major grabens has been interpreted as indicating renewed movement along the faults during or following deposition of the Cretaceous rocks (Ross, 1963). The last major movements, which deformed the Pennsylvanian rocks, probably occurred at the time of the last major tectonic disturbances in the eastern part of the continent—the Appalachian Revolution at the end of the Paleozoic Era. Since that time, the development of the Mississippi Embayment Syncline and renewed uplift of the Ozark Dome have gently warped the Cretaceous and Tertiary strata.

**Unconformities**—Unconformities are a major factor in the structure and distribution of the bedrock formations in Illinois. Seven major unconformities produced by widespread withdrawal of the sea, erosion, and readvance of the sea, accompanied by significant tectonic disturbances, are recognized in Illinois (fig. 1). Four other unconformities show no significant deformation. The erosion that produced the unconformities is generally considered to be subaerial—by rivers and streams—but at least parts of some unconformities may well be produced by marine planation. Local unconformities that occur on the flanks of the Illinois Basin are due to fluctuations in the margins of the seas.

Diastems (intervals of nondeposition) are abundant in some formations and locally account for the absence of units where no unconformity is present. During these intervals corrosion surfaces were produced in some places by the solution of the sea floor. In local areas, particularly near faults, solution has removed buried carbonate units many feet thick, simulating an unconformity. Solution

thinning is most apparent in stylolitic bedding surfaces, which in some carbonate formations are abundant enough to suggest that many feet of rock may have been dissolved.

The major unconformities have regional continuity throughout much of the continent, and, as they represent significant events in the geologic history of any region, they are used in stratigraphic classification as boundaries delineating units called sequences (Sloss, 1963). The sequences recognized in Illinois (fig. 14) have strongly overlapping relations. They indicate the major intervals of relative tectonic stability, although progressive sinking of the Illinois Basin continued.

The sub-Cretaceous unconformity at the base of the Embayment Sequence developed during the long interval between Pennsylvanian and late Cretaceous time, during which several thousand feet of Paleozoic strata, and also any early Mesozoic strata that may have been present, were eroded. The truncation of several thousand feet of Pennsylvanian strata across anticlinal structures requires the same amount of general lowering of the surface by erosion. It has also been estimated that to reach their present degree of coalification Pennsylvanian coals must have been buried by sediments about a mile thicker than those now present (Damberger, 1971). The eroded rocks may have included some of Permian age, because marine Permian rocks found in eastern states probably were deposited in a sea that advanced eastward across Illinois, Indiana, and Ohio. In most of the area where the Cretaceous and Tertiary strata are absent, erosion may have continued into Pleistocene time and perhaps even to the present in the driftless areas, but projections of the sub-Cretaceous unconformity in southern Illinois to the area of Cretaceous rocks in western Illinois and to central Iowa suggest that most of the truncation of the Paleozoic rocks occurred before late Cretaceous time.

**Bedrock Surface**—The top of the bedrock is marked by deep valleys that were incised mainly during the early part of the Pleistocene Epoch (fig. 15). As a result, the deposits of the Pleistocene overlie, and in many areas completely conceal, a surface dissected by major valleys as much as 400 feet deep, many with tributaries entrenched 100-200 feet. The variety of unconsolidated surficial rocks that unconformably overlie the bedrock surface reflects (1) the climatic changes from rigorous glacial climates to interglacial climates somewhat warmer than those of the present, (2) the various agents of transportation (glacial, fluvial,

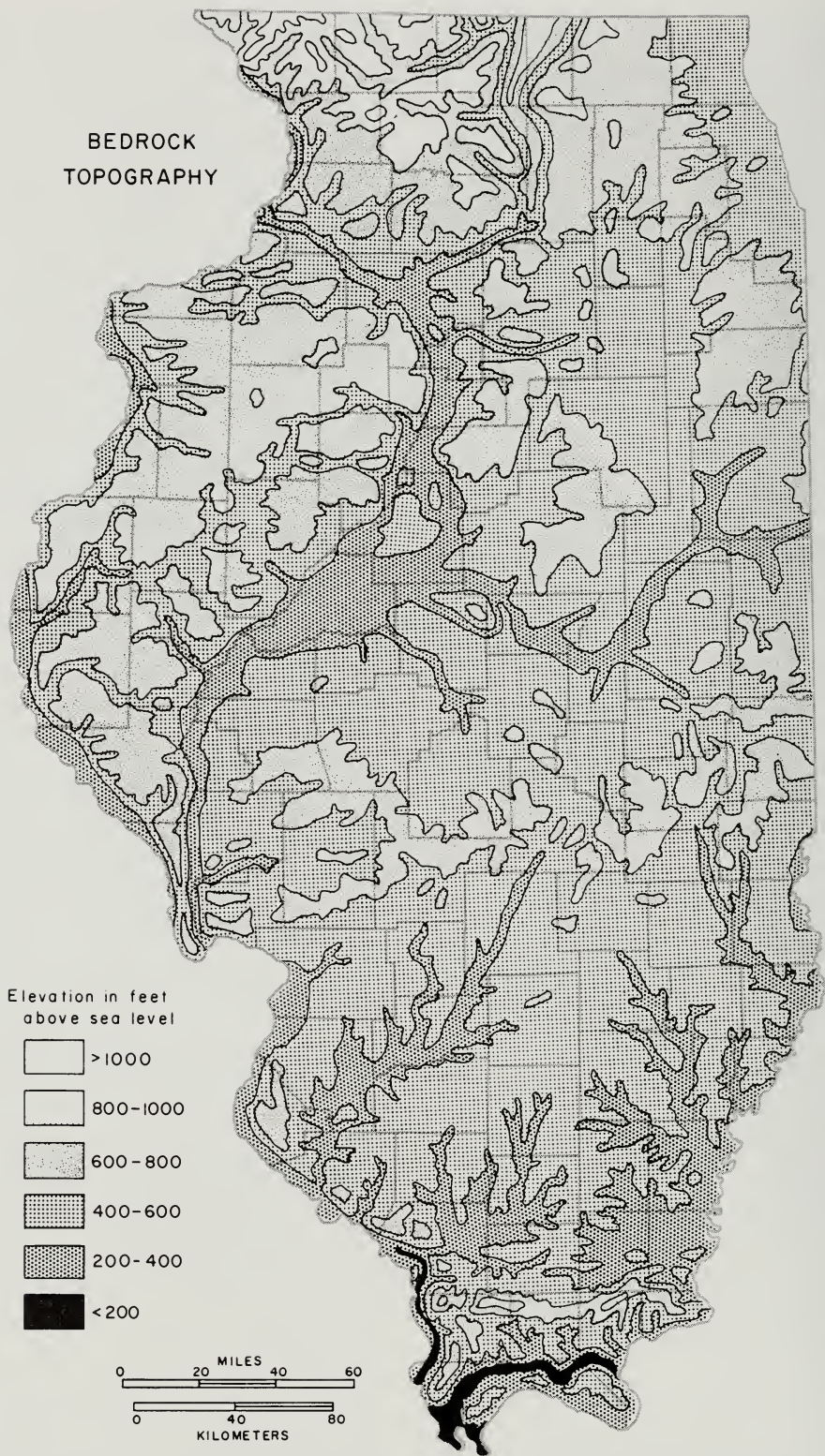


Fig. 15—Topography of the bedrock surface of Illinois (after Horberg, 1950a, and Willman and Frye, 1970).

al, and eolian), and (3) the environments in which the sediments were deposited—hills and flat uplands, valleys and lowlands, and lakes and swamps. The surficial sediments are of special interest because they are the rocks on which we live, the soil that provides our food, the mineral resources with which we build, and the source of much of the water we drink.

### *Stratigraphic Classification*

In the early reports on the geology of Illinois only a few terms were used in stratigraphic classification (fig. 16), and those were used somewhat inconsistently. Most of the named units were called formations and assigned to a system, a unit designating age. By the late 1800s, the rapidly increasing number of named units made apparent the need for a more systematic classification. Largely following recommendations by the International Geological Congress of 1901, a classification was developed that had one set of terms for rock units and another for equivalent units of time. That classification was used in Illinois from about 1910 to 1958.

The same classification was accepted, with minor changes, in the stratigraphic code of 1933, which was drawn up by a committee representing several national organizations (Ashley et al., 1933). The classification was later modified to meet the particular conditions in the Pennsylvanian and Pleistocene rocks. These modifications, however, did not change the fundamental parallelism of the rock and time terms, and in effect retained the single classification scheme.

In the 1940s and 1950s, concern increased regarding the inadequacies of the single classification scheme for precise communication. Use of the same name for a rock unit and its time of deposition often resulted in confusion. In many reports it was not clear whether a reference to time of deposition of a unit referred to the interval from its oldest to its youngest part regionally, to the time represented by deposition of the type section, or to the time of deposition in the local area described. To avoid this confusion, completely independent classifications were devised for rock units based on lithology and rock units based on time of deposition, the latter serving as the basis for geologic time classification.

This multiple classification scheme brought about the development of other independent stratigraphic classifications, each based on the need for recognition of units differentiated by some particular characteristic of the rocks.

The multiple classification scheme was adopted by the Illinois State Geological Survey in 1958 (Willman, Swann, and Frye), at which time six classifications were recognized—classifications based on lithology, time of deposition, paleontology, cycles of sedimentation, facies, and soils. Since then, classifications based on unconformities (Sloss, 1963; Sloss et al., 1949; Swann and Willman, 1961), morphology, or surface expression (Frye and Willman, 1962; Willman and Frye, 1970), and hydrogeology (Maxey, 1964) have been recognized in Illinois (fig. 16).

Of the nine classifications recognized, only rock- and time-stratigraphic classifications apply to all rocks. All rocks belong to some formation in the rock-stratigraphic classification, and all formations are assigned to some system or systems in the time-stratigraphic classification. The other rock and time units and the other classifications are used only when needed. The other classifications have more limited application and are described briefly in the sections pertaining to the systems for which they are most useful.

The rock-stratigraphic classification, which differentiates units of rock distinguished by lithologic characteristics recognizable in the field, is designed as the basic framework for stratigraphic description, for areal geology, for geologic structure mapping, and for various economic purposes. The formation, which is the fundamental unit, has a distinctive lithology or a characteristic variation in lithology, and adequate thickness and lateral extent to meet the practical requirements of the classification. In general, it is traced laterally through changes in lithology as far as the boundaries in its type locality can be traced with confidence, but beyond that area another formation is differentiated. The boundaries of rock-stratigraphic units commonly transect time surfaces; in fact, they are marked in many cases by vertical cut-offs, which are steps used to maintain lithologic unity (figs. 14, Q-8). Rock-stratigraphic units do not intertongue and therefore do not recur in a vertical section. In contrast, facies units, which commonly have intricate intertonguing and gradational boundaries and are more restricted lithologic types, generally are independent of rock-stratigraphic classification. Similarities between adjacent formations are shown by their grouping into subgroups, groups, and megagroups (fig. 16). Subdivisions of formations are based on minor characteristics or on units too thin to be classified as formations and are recognized as members and beds.

isotopic dating, unconformities, bentonites, and other distinctive and persistent lithologic characteristics are used for time-stratigraphic classification, particularly in small regions. The system, the fundamental unit of the classification, is the smallest unit generally applicable on a world-wide basis. Units progressively lower in rank—series, stage, substage—are differentiated by relative significance and commonly have only regional usefulness.

BEFORE 1910		1958 — PRESENT	
(Worthen, 1866; Weller, 1906)		(Willman, Swann, & Frye, 1958; Kosanke et al., 1960; American Commission on Stratigraphic Nomenclature, 1961; Swann & Willman, 1961; Swann, 1963; Maxey, 1964; Willman & Frye, 1970; Frye & Willman, 1970)	
System Group Formation		I. ROCK-STRATIGRAPHIC CLASSIFICATION (Units of rock differentiated on lithology)	
		Megagroup Group Subgroup Formation Member Bed	
1910-1932		II. TIME-STRATIGRAPHIC CLASSIFICATION	
(Carman, 1910; Cady, 1919; Wanless, 1929)		(Units of rock differentiated on time of deposition)	
Rock	Time	III. BIOSTRATIGRAPHIC CLASSIFICATION	
Group	Era	(Units of rock differentiated on the basis of paleontology)	
Subgroup		Range of single taxon	
System	Period	Range-zone	
Subsystem		Abundance of single taxon	
Series	Epoch	Peak-zone	
Formation	Stage	Fauna or flora	
		Assemblage-zone	
1932-1958		IV. CYCLICAL CLASSIFICATION	
(Wanless & Weller, 1932; Ashley et al., 1933; Willman & Payne, 1942; Wanless, 1957)		(Units of rock differentiated on sedimentary cycles)	
Rock	Time	(Corresponding unit of geologic time)	
General		Cyclothem	
		Cycle	
System	Era	V. FACIES CLASSIFICATION	
Series	Period	(Units of rock differentiated on lateral changes in composition)	
Group	Epoch	Facies (informal lithologic name)	
Formation	Epoch	VI. SOIL-STRATIGRAPHIC CLASSIFICATION	
Member	Stage	(Units of rock differentiated on weathering profiles)	
	Substage	Soil	
Pennsylvanian		VII. UNCONFORMITY-BASED CLASSIFICATION	
System	Period	(Units of rock bounded by unconformities)	
Group		Sequence	
Cyclothem	Cycle	VIII. MORPHOSTRATIGRAPHIC CLASSIFICATION	
Member		(Units of rock differentiated on physiographic expression)	
Pleistocene		Drift	
Series	Epoch	Terrace (informal name)	
Stage	Age	IX. HYDROSTRATIGRAPHIC CLASSIFICATION	
Substage	Sub-age	(Units of rock differentiated on hydrologic properties)	
		Aquifer	

Fig. 16—Development of the stratigraphic classifications used in Illinois. The references include reports that introduced changes in the classification and others that show typical usage.

The terms "lower," "middle," and "upper" for rock- and time-stratigraphic units and "early," "middle," and "late" for time units are used only informally to indicate relative position, and they are not capitalized. The only exception is for the Devonian System, in which geographic terms have not been accepted for the names of series and Lower, Middle, and Upper Devonian Series continue to be used.

The various classifications used in Illinois conform in principle and in most details to the stratigraphic code adopted by the American Commission on Stratigraphic Nomenclature (1961), which at present formally recognizes only classifications based on lithology, time, paleontology, soils, and geologic climate.

### Nomenclature

The terms used in descriptions of lithology follow common field usage, but they differ somewhat because of individual preferences of the authors, particularly in descriptions of carbonate rocks. In general, the Wentworth classification is used in descriptions of grain size of clastic rocks. The patterns and symbols used in the figures are identified in figure 17.

### Thickness Maps

Explanations not fully given in the legends of the thickness maps are as follows:

1) Isopachs are drawn only in the area where the named unit is overlain by the next younger unit.

2) The "outcrop areas" are those where the unit is exposed or directly underlies unconsolidated surficial materials—glacial drift, alluvial materials, loess, or Cretaceous and Tertiary sediments. As the top of the unit is eroded, no isopachs are drawn in these areas.

3) The term "Eroded" refers to areas of the bedrock surface where the unit has been entirely eroded. On some maps, areas in subsurface where the unit was eroded at a major unconformity are differentiated.

4) The term "Absent" is applied to areas where the unit was never deposited and the boundary is at (or close to) a shoreline; it also applies to areas where the absence of the unit results from a change in facies and the boundary is a vertical cut-off.

5) Closed areas of thinning are indicated by hachures.

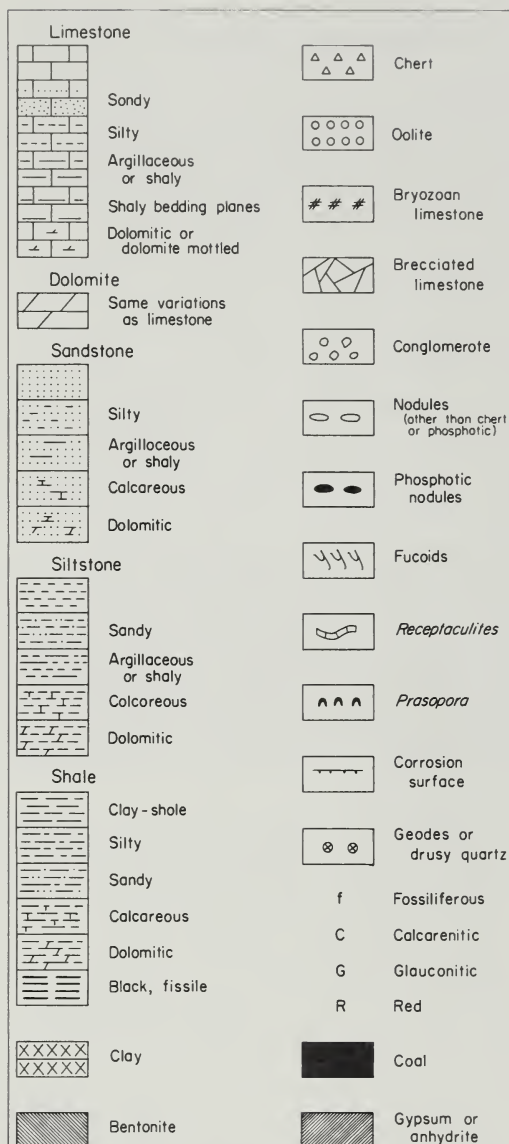


Fig. 17—Patterns and symbols used in figures.

6) Many of the thickness maps are generalizations from detailed maps in the Illinois State Geological Survey files.

### Styling

In the following descriptions of the stratigraphic units, the formal name of the unit is followed by the reference to the person or persons who introduced the name, after which appear the names of those who made significant redefinitions, not including changes in rank.

Units are described from oldest to youngest in the order in which they first appear in the section, and once introduced they are not repeated.

The illustrations for each system of rocks are numbered separately. Figure numbers for all except the Introduction are preceded by a

code letter indicating the relevant system. Specifically, the prefix "Pc" indicates Precambrian, "C" Cambrian, "O" Ordovician, "S" Silurian, "D" Devonian, "M" Mississippian, "P" Pennsylvanian, "K" Cretaceous, "T" Tertiary, and "Q" Quaternary.

## PRECAMBRIAN ROCKS

### *Elwood Atherton*

The Precambrian rocks, which are commonly referred to as the basement, lie at depths ranging from about 2000 feet below the surface in the northernmost part of Illinois to about 14,000 feet below the surface in the deepest part of the Illinois Basin in southern Illinois (fig. Pc-1). Only 20 borings have penetrated and sampled the Precambrian basement in Illinois.

Illinois is part of a Precambrian granite-rhyolite terrane, relatively uniform in rock type and age, that extends from the Mississippi River eastward into Ohio (Rudman et al., 1965). Aeromagnetic maps of Illinois show a strong, anomalous magnetic gradient band parallel to and along the Rough Creek Fault Lineament in southern Illinois, indicating that this may be a zone of significant intrusive activity. The anomaly pattern shows an over-all homogeneity north of the lineament, suggesting a rough uniformity in composition of the deep rocks in that area. The gravity map of Illinois shows regionally denser crust south of this lineament (Heigold, in preparation).

Age determinations for the uppermost Precambrian rocks in Illinois range, with one exception, from about 1100 to 1400 million years (m.y.) (Lidiak et al., 1966) and fall within the Precambrian Y time unit designated by the United States Geological Survey (James, 1972). The exception was the determination made on granite samples from one well in La Salle County, which gave the anomalously low age of only 640 m.y. If correct, that date suggests that younger Precambrian rocks may be present in local areas. Because Cambrian deposition in Illinois probably began about 525 million years ago in Croixan

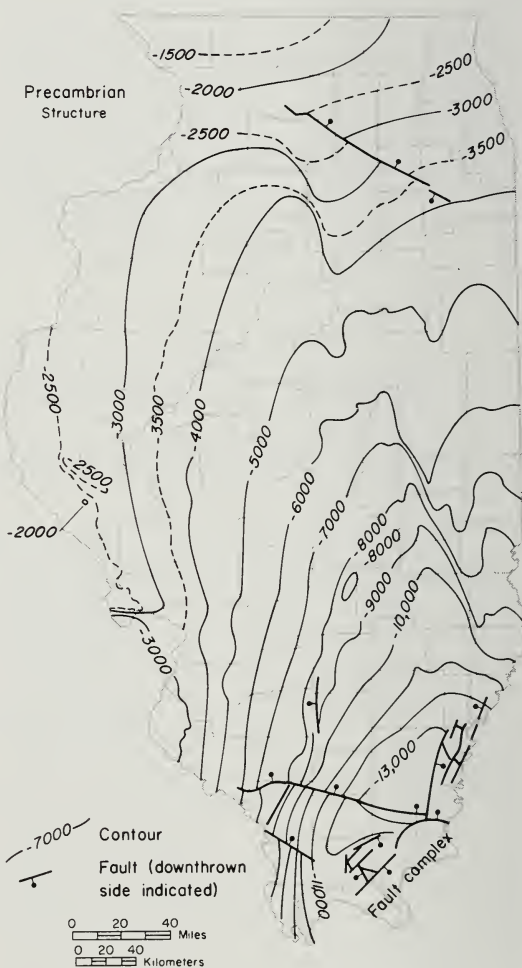


Fig. Pc-1—Structure on top of the Precambrian basement.

(late Cambrian) time (fig. 1), the unconformity on the Precambrian rocks represents an interval of 600 to 900 m.y.

The buried surface of the Precambrian, where it can be adequately studied, is hilly (Atherton, 1971). In Pike County in western Illinois, two deep tests 8 miles apart reveal a relief of about 800 feet on the Precambrian surface. Several tests found the basal Cambrian Mt. Simon Sandstone unexpectedly thin or absent over the Precambrian. Presumably, these wells encountered Precambrian hills too high to have been covered by the regional blanket of Mt. Simon Sandstone. Too few Precambrian tests have been drilled in the deep part of the Illinois Basin to indicate the local relief, but, if information from adjacent states is a reliable indication, the relief may be several hundred feet. Wells that pass through the Mt. Simon normally enter fresh-looking igneous rock. The feldspar grains in the arkose forming the base of the Mt. Simon and in the underlying granitic rock also have a fresh appearance. Any weathered material that may once have accumulated was evidently eroded before deposition of the Paleozoic sediments.

The Precambrian rocks from the 20 borings in Illinois have included 10 red granites, 4

pink granites, one gray granite, 4 granodiorites (two of which occur in the same wells as granites), one felsite (in the same well as granite), one rhyolite, one red granophyre, and one red-brown granite porphyry (Grogan, 1949; Bradbury and Atherton, 1965). All but one of the granites contain potash feldspar and quartz as the chief constituents, various amounts of plagioclase, and biotite as the chief dark mineral. The other granite, from Will County, is alkalic and contains riebeckite rather than biotite. Apatite and zircon are present in all the granites, and sphene, fluorite, epidote, and allanite occur in many. The granites are medium to coarse grained, and most appear to be somewhat porphyritic.

The granodiorites are similar to the granites but contain greater amounts of ferromagnesian minerals. The rhyolite is porphyritic, with phenocrysts of quartz and red feldspar in an aphanitic groundmass. The granophyre in composition falls between the compositions of the granite and the rhyolite; it contains an abundance of micropegmatite. No mafic igneous rocks or metasediments have been encountered in the basement of Illinois, but reports of these rock types in the Precambrian of adjacent states suggest that they may be present.

## PALEOZOIC ERATHEM

*H. B. Willman*

The Paleozoic Erathem—the rocks deposited during the Paleozoic Era (Sedgwick, 1838)—originally included only the rocks now referred to the Cambrian, Ordovician, Silurian, and Devonian Systems, but the definition of the name was expanded in 1840 to include the Carboniferous (Mississippian and Pennsylvanian) and Permian Systems (Phillips, 1840), and present usage follows that definition.

The Paleozoic rocks of Illinois (fig. 1) are separated from the older Precambrian and younger Mesozoic rocks by great unconformities. The basal unconformity is marked by the absence of rocks of late Precambrian and ear-

ly and middle Cambrian age, an interval approximately as long as all the time that has passed since then—more than half a billion years. The unconformity at the top of the Paleozoic represents more than 125 million years and is marked by the absence of the youngest Pennsylvanian, the Permian, and all the Mesozoic rocks older than late Cretaceous. Between these unconformities the Paleozoic Erathem in Illinois contains sediments representing the oldest six of the seven systems.

The Paleozoic rocks are dominantly marine sediments, representing repeated invasions of the sea into the interior of the continent. The

seas generally advanced from the south, and the land-derived sediments deposited in them came mainly from the north, northeast, and east, with smaller amounts from sources in the southeast and northwest. Very small contributions came from the Ozarks to the west. Above the thick sandstones of the Cambrian System, carbonate sediments are dominant through the middle Mississippian, whereas shale and sandstone dominate the younger deposits. Sandstones in the Cambrian and up through the Devonian rocks consist mainly of well rounded quartz grains and a minor amount of stable heavy minerals of a limited suite. Many are almost entirely quartz sand, but others contain some clay, silt, and more varied heavy minerals. The sand of the early Paleozoic sandstones was reworked largely from late Precambrian sandstones and has passed through several cycles of erosion and transportation. The Mississippian and early Pennsylvanian sandstones are largely quartz sandstones but are not as well rounded or sorted or as pure as the older sandstones, which suggests that the sources of the older sandstones were being covered by the Paleozoic sediments. The later Pennsylvanian sandstones are noticeably angular, poorly sorted,

silty, feldspathic, and micaceous, and have a larger suite of only moderately stable heavy minerals. They appear to be first-cycle sediments derived from more recently exposed or accessible granitic and metamorphic rocks.

The term "Paleozoic" means ancient life, and fossils of the Paleozoic rocks represent the oldest abundant life. Algal-like fossils and burrows and trails of worm-like organisms are found in the Precambrian rocks of other regions, but only rarely. A great variety of marine invertebrate animals characterized the Paleozoic Era. Marine vertebrates (fishes) developed during Ordovician time, but it was not until Devonian time that plants became abundant enough on land to furnish the food that permitted fresh-water and land-dwelling animals to develop. Although fossils are scarce in Illinois Cambrian rocks, they are abundant in many other Paleozoic strata. By late Mississippian time plants were abundant, and during the Pennsylvanian Period they flourished profusely. In swampy areas they accumulated and eventually formed coal beds. Amphibious vertebrates became more common late in the Paleozoic, but invertebrates continued to be the dominant form of animal life throughout the era.

## CAMBRIAN SYSTEM

*T. C. Buschbach*

The Cambrian System (Sedgwick, 1835, p. 390) is named for Cambria, the Roman name for northern Wales, where the type section is well exposed. All Cambrian sediments in Illinois are considered late Cambrian in age and are assigned to the Croixan Series. However, as the Mt. Simon Sandstone (at the base), which forms more than half the system in the northern two-thirds of the state, contains no fossils, middle and early Cambrian strata could be present even though not identifiable (Bell et al., 1964). The possibility that Precambrian sandstones also may be represented in the Mt. Simon (Workman and Bell, 1948) seems less likely (Templeton, 1950).

The Cambrian System is differentiated from the overlying Ordovician in northern Illinois

by both fossils and lithology, but in much of southern Illinois, where the contact is deeply buried and has been penetrated in only a few borings, Cambrian and Ordovician rocks consist of similar types of dolomite. Consequently, the boundary may occur within an interval of several hundred feet.

Cambrian strata underlie all of Illinois, but they are exposed only in relatively small areas in Ogle and Lee Counties (Bevan, 1935, 1939; Willman and Templeton, 1951) (fig. C-1). However, they directly underlie thick glacial drift in a larger area in Lee and De Kalb Counties (Weller et al., 1945; Willman et al., 1967), where they occur on the south, or upthrown, side of the Sandwich Fault (fig. 10). Cambrian rocks range from about 1000

feet thick in southwestern Illinois to more than 3500 feet in the eastern part of the state (fig. C-2).

Cambrian strata in Illinois are dominantly sandstone, which is generally white but locally is stained or mottled red or yellow. The sand is subangular to well rounded, poorly to

well sorted, and predominantly medium grained, although it varies from fine to coarse grained and some beds contain small quartz pebbles. Much of the sandstone is friable, dominantly quartz, and noncalcareous. The basal zone, as much as 350 feet thick, is strongly arkosic. In extreme northern Illinois

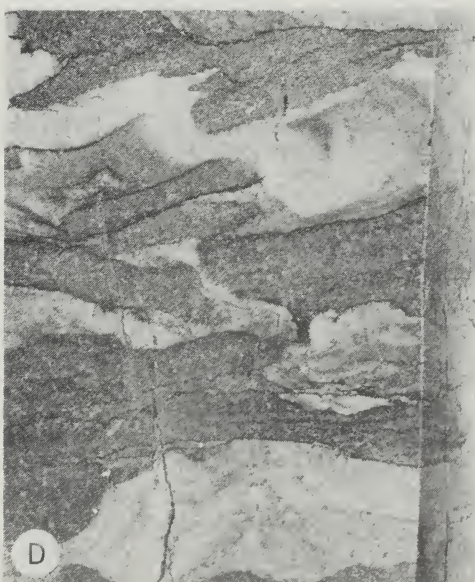
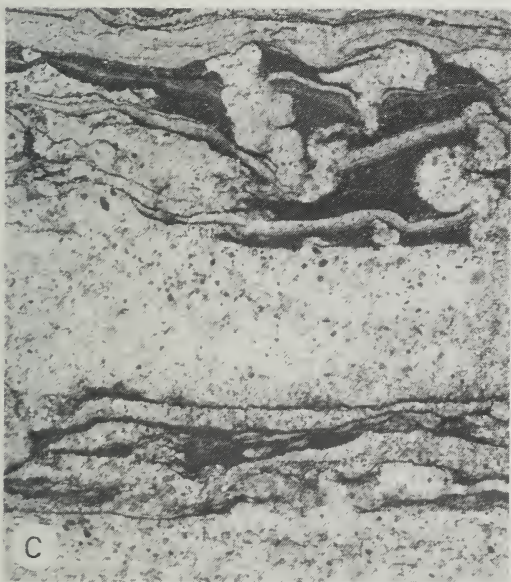


Fig. C-1—Exposures and cores of Cambrian rocks.

A—Massive Potosi Dolomite in a quarry 4 miles northwest of Ashton, Ogle County.

B—Cambrian-Ordovician unconformity showing well bedded Oneota Dolomite overlying massive Potosi Dolomite in a quarry in Lee County, 6 miles south of Rochelle, Ogle County (Willman and Templeton, 1951, p. 113).

C—Core of Eau Claire Formation showing penecontemporaneous deformation of shale beds in shaly sandstone; from a boring in Champaign County ( $\times 2$ ).

D—Core of Ironston Sandstone showing flat-pebble conglomerate; from a boring in Champaign County ( $\times 2$ ).

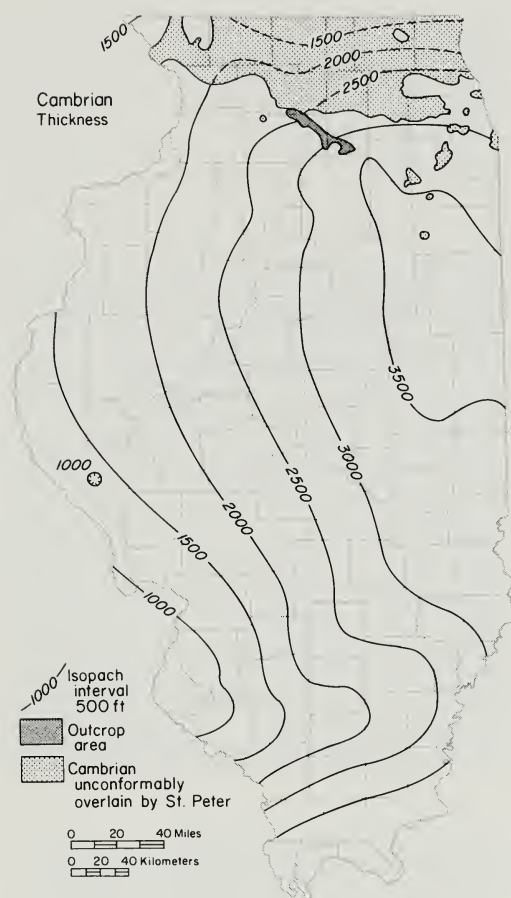


Fig. -C-2—Thickness of the Cambrian System. The dashed lines show reconstructed thicknesses.

the Cambrian System, although 90 percent sandstone, contains a persistent dolomite, the Potosi Formation (fig. -C-3). The Franconia Formation, the upper part of the Ironton Sandstone, and the Eau Claire Formation contain dolomitic sandstone. As these three units thicken southward and grade into dolomite, the proportion of sandstone diminishes to probably no more than 25 percent in extreme southern Illinois (fig. -C-4).

Classification of the Cambrian rocks in Illinois is based largely on classifications that developed in the late 1800s in the outcrop areas to the north in Wisconsin and Minnesota and to the southwest in Missouri, long before the few Cambrian outcrops in Illinois had been recognized. Deep drilling, primarily for ground water, in the Chicago area and later in scattered localities throughout the state, penetrated the Cambrian formations and permitted correlations with the outcrop areas (fig. -C-5).

More recently, some units not present or not recognized in the outcrop areas have been differentiated in the very thick subsurface Cambrian sections in Illinois by studies of samples from borings (Templeton, 1950; Buschbach, 1964).

The dominantly sandstone units in the lower part of the Cambrian System are collectively called the Potsdam Sandstone Megagroup (figs. 14, -C-3), and the upper dolomite units are referred to the Knox Dolomite Megagroup, which extends upward to include Ordovician dolomite formations. An interval of interbedded sandstone, siltstone, shale, and dolomite units separates the Potsdam and Knox Megagroups, except in southwestern Illinois (fig. -C-4).

The Cambrian System rests with major unconformity (the sub-Sauk unconformity) (fig. 14) on Precambrian igneous rocks (Pc-1), most of which are granite. The Precambrian surface is commonly referred to as a peneplain, but knobs of Precambrian rocks as much as 500-1000 feet high rise sharply into the Cambrian rocks (Workman and Bell, 1948; Ather-ton, 1971). Only a few such knobs are known in the Illinois Basin, most of them marginal to the Ozark region, but many others may exist.

The Cambrian System is generally separated from the overlying Ordovician System by a sharp change in lithology, but no erosional or structural evidence of an unconformity is apparent. Similar relations exist between rock-stratigraphic units within the Cambrian, but many have transitional contacts. The next higher major unconformity is the sub-Tippes- canoe unconformity at the base of the St. Peter Sandstone or Everton Formation. Cambrian and Ordovician strata in the interval of relatively parallel units (fig. 14) between the sub-Tippes- canoe unconformity and the basal Cambrian unconformity are referred to the Sauk Sequence.

The sand that composes most of the Cambrian rocks in Illinois was derived almost entirely from the region to the north and was deposited in a marine embayment. The roundness of the grains and the presence of a suite of stable heavy minerals, limited both in variety and quantity, suggest that most of the sands were derived from Precambrian, or possibly early Cambrian, sandstones, which at that time probably covered a large area of the Canadian Shield. In some beds the more varied suite of heavy minerals typical of granitic terranes indicates occasional erosion by the rivers through the sandstones into the Precambrian granites, but the characteristics of most

of the sands suggest they had passed through at least one and possibly several cycles of erosion, transportation, and deposition. The highly arkosic basal sandstone may have been derived from closer sources. In southwestern Illinois the sand probably came from the Ozark region, which was strongly dissected before late Cambrian time. In eastern and southern Illinois, beds of shale in the Cambrian strata appear to be continuous, have thicker units to the south and southeast, and were probably derived from Appalachian sources.

All the sandstones above the Mt. Simon, and possibly even the uppermost Mt. Simon, grade southward through dolomitic sandstone and sandy dolomite facies into dolomite that is relatively pure, except for some beds that contain chert, drusy quartz, and glauconite. The southward thickening of the dolomite and the lack of recognizable unconformities suggest the progressive sinking of the Illinois Basin during Croixan time. The bordering positive areas, and in fact much of the interior of the continent, were submerged by the seas during that time, and perhaps only the higher areas of the Canadian Shield remained as land.

Fossils are scarce in Cambrian sediments, but the seas were not without life; trilobite debris forms black streaks in some beds. The fauna has not been intensively studied, but Raasch (Willman and Templeton, 1951) reported *Dikelocephalus*, *Illiaenurus*, and *Saukiella*, as well as unnamed species of trilobites from the Franconia exposures at Oregon, Ogle County, and *Cryptozoon*, *Hypseloonus*, and *Saukiella* from outcrops of the Potosi Formation. Oboloid brachiopods, gastropods, algal domes, and worm borings also are present but poorly preserved. The fauna is much better known in Wisconsin (Twenhofel et al., 1935; Raasch, 1951), Minnesota (Bell et al., 1956), and Missouri (Lochman-Balk, 1956).

CROIXAN SERIES

The Croixan Series (Winchell, 1873, p. 70; 1900), named for the St. Croix River in eastern Minnesota, has also been called the Upper Cambrian, the St. Croix, and the St. Croixian Series. The type section consists of all strata of Cambrian age (about 600 feet) exposed in the St. Croix Valley. There Cambrian strata overlie Precambrian rocks, and the uppermost Cambrian formation, the Jordan Sandstone, is overlain by the Oneota Dolomite, the oldest

Ordovician formation in that area. The Croixan Series is defined on the basis of its trilobite faunas; it extends from the *Cedaria* Zone at the base to the *Plethopeltis* Zone (Howell

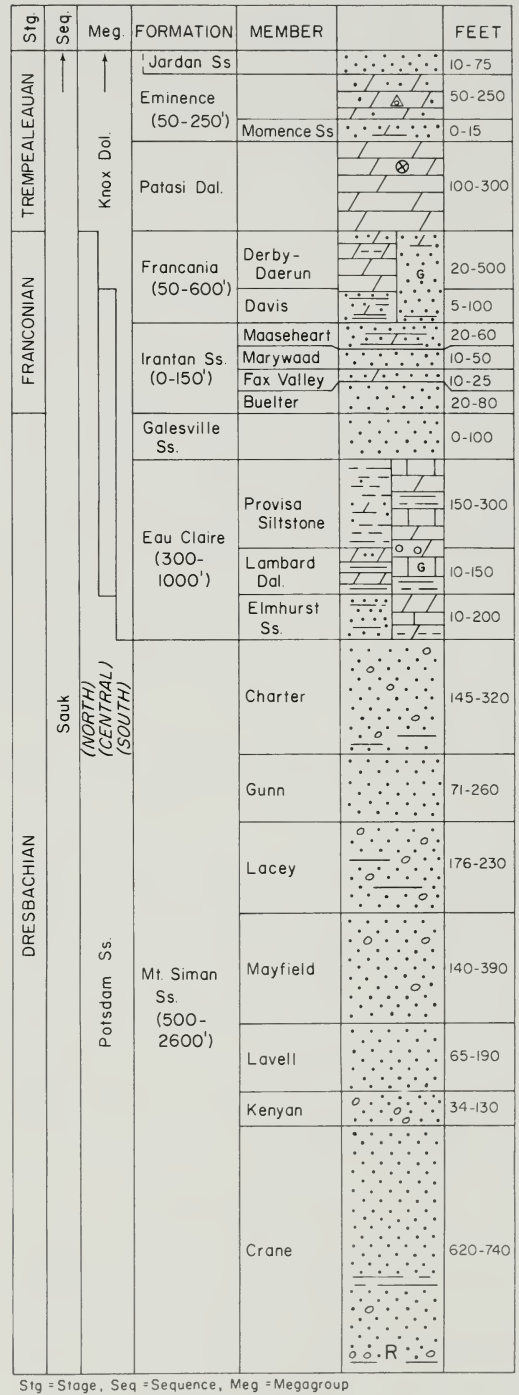


Fig. C-3—Columnar section of the Cambrian System.

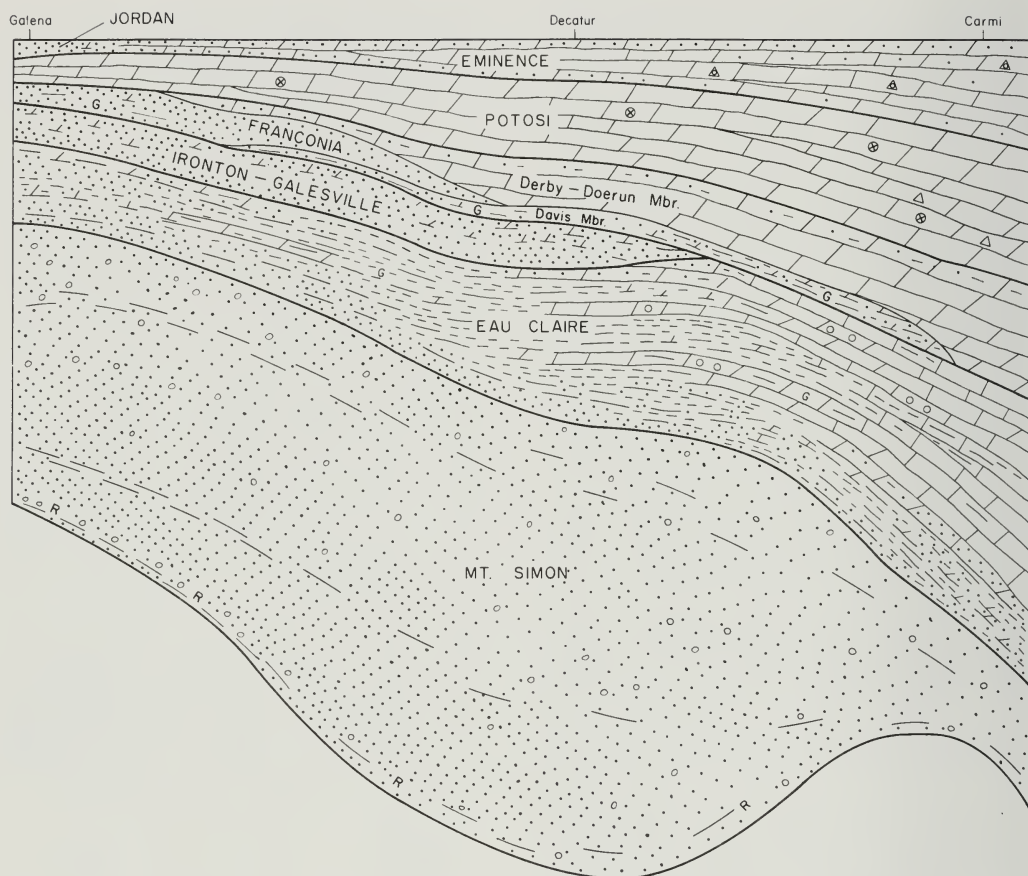


Fig. C-4—Diagrammatic cross section of the Cambrian System from northwestern to southeastern Illinois.

et al., 1944) or the *Saukia* Zone (Raasch, 1951) at the top. The Croixan Series is subdivided into the Dresbachian (oldest), Franconian, and Trempealeauan Stages (fig. C-3). All Cambrian strata in Illinois are assigned to the Croixan Series. The thickness of the Croixan, therefore, is the same as that for the Cambrian System (fig. C-2). Information about Cambrian rocks in extreme southern Illinois is scarce and middle, or even lower, Cambrian strata may be present in that part of the Illinois Basin.

### Dresbachian Stage

The Dresbachian Stage (Winchell, 1886, p. 334-337), named for Dresbach, Winona County, Minnesota, consists of all strata of Croixan age below the *Elvinia* Zone. It includes the *Cedaria* (oldest), *Crepicephalus*, and *Aphelaspis* Zones (Howell et al., 1944). In Illinois the stage is represented by 1500-3500 feet of sandstone and dolomite that

is differentiated into the Mt. Simon Sandstone (below), the Eau Claire Formation, and the Galesville Sandstone. As the Mt. Simon and Galesville Sandstones lack fossils, the precise boundaries of the stage are uncertain (Buschbach, 1964). These strata were originally called the Dresbach Sandstone (or Formation) and in some areas are now referred to as the Dresbach Group.

### SAUK SEQUENCE

The Sauk Sequence (Sloss et al., 1949, p. 111), named for Sauk County, Wisconsin, consists of all strata between the unconformity on the top of the Precambrian rocks and the sub-Tippecanoe unconformity at the base of the St. Peter Sandstone or Everton Formation. In Illinois it therefore includes all strata of Cambrian and Canadian (lower Ordovician) age (fig. 14). Local channeling at the base of some of the sandstones may have been mainly submarine and no unconformities are recog-

nized within the sequence. The sequence was uplifted by gentle warping and minor faulting and was deeply eroded before deposition of the overlying Tippecanoe Sequence (Atherton, 1971).

POTSDAM SANDSTONE  
MEGAGROUP

The Potsdam Sandstone Megagroup (Emmons, 1838, p. 214-217, 230), named for Potsdam, St. Lawrence County, New York, consists of the dominantly sandstone formations that compose the lower part of the Cambrian strata in the Illinois Basin. The megagroup underlies all of Illinois but is not exposed. It has a maximum thickness of more than 2600 feet in northeastern Illinois. The name "Potsdam" was widely used in early reports for the basal Cambrian sandstone, but later its use was restricted to the type region. It was reinstated for the megagroup by Swann and Willman (1961) (figs. 14 and C-3). Traced southward from southern Wisconsin, where the entire Cambrian section is included in the Potsdam, the clastics become finer

grained and grade to dolomite that is included in the Knox Megagroup. Throughout most of Illinois, however, the megagroups are separated by a zone of mixed dolomite, siltstone, and sandstone that is not included in either group. In the northern tier of counties in Illinois, the top of the Potsdam is commonly the top of the Franconia Formation. In the rest of the northern and in the central part of the state, the top is placed at the top of the lowest member (Elmhurst) of the Eau Claire Formation. In southern Illinois, the top of the Potsdam is the top of the Mt. Simon Sandstone.

Mt. Simon Sandstone

The Mt. Simon Sandstone (Ulrich, in Walcott, 1914, p. 354) is named for Mount Simon, an escarpment near Eau Claire, Wisconsin, where the type section consists of 234 feet of coarse-grained, partly conglomeratic sandstone overlying Precambrian granite and overlain by fine-grained sandstone of the Eau Claire Formation. The Mt. Simon Sandstone, although not exposed, underlies all of Illinois except in local areas where it failed to cover hills on the Precambrian surface. It ranges from less than 500 to 2600 feet thick, with the greatest thickness in northeastern Illinois (fig. C-6). The Mt. Simon consists of

Anderson 1919	Thwaites 1923, 1927	Workman 1935	Willman and Payne 1942		Workman and Bell 1948 <i>SOUTH      NORTH</i>		Present Buschbach 1964, 1971	
	Mendota	Jordan-Gunter	Jordan		Eminence	Gunter-Jordan	Jordan	Eminence
	Jordan							Members
							Momence	
	Trempealeau	Trempealeau	Trempealeau		Potosi	Trempealeau	Potosi	
	Mazomanie	Franconia	Franconia		Derby-Doerun	Franconia	Franconia	Derby-Doerun
					Davis			Davis
		Ironton M.	Ironton M.			Ironton M.	Ironton	Mooseheart
Jordan	Dresbach	Galesville	Dresbach Group	Galesville	Galesville	Marywood		
						Fox Valley		
						Buelter		
						Galesville		
St. Lawrence	Eau Claire	Eau Claire		Eau Claire	Bonne Terre	Eau Claire	Eau Claire	Proviso
								Lombard
								Elmhurst
Dresbach	Mt. Simon	Mt. Simon	Dresbach Group	Mt. Simon	Lamotte	Mt. Simon	Mt. Simon	Charter
								Gunn
								Lacey
						Mayfield		
						Fond du Lac ?		Lovell
								Kenyon
								Crane

Fig. C-5—Development of the classification of the Cambrian System.

fine- to coarse-grained, partly pebbly, friable sandstone, most of which is coarser grained, more poorly sorted, and more angular than younger Cambrian and Ordovician sandstones. The pebbles, mostly quartz, are as much as 8 mm in diameter in central northern Illinois and only 3.5 mm in northeastern Illinois. Most of the sandstone is white, but in some areas much of it is red, particularly the lower part, and in other localities some of it is yellow to light greenish gray. A basal zone, as much as 350 feet thick, is strongly arkosic. Beds of red and green micaceous shale, in some places 15 feet thick, occur, especially in the upper 300 feet and the lower 600 feet of the formation. Relatively fine-grained units alternate with coarse-grained, pebble-bearing units to divide the Mt. Simon into seven members: Crane Member, at the base (fine to medium grained), Kenyon Member (pebbly), Lovell Member (medium grained), Mayfield Member (interbedded pebbly and medium grained), Lacey Member (pebbly), Gunn Member (medium grained), and Charter Member (pebbly). These units are recognized in borings in north-central Illinois (Templeton, 1950), but have not been traced throughout the state. Only the upper three have been recognized in northeastern Illinois (Buschbach, 1964). The base of the Mt. Simon is the sub-Sauk unconformity. The contact with the overlying Eau Claire Formation is conformable. The Mt. Simon is probably entirely marine, but its characteristics are unknown in a large part of the state. The lower part of the formation has been correlated with Cambrian and Precambrian sandstones in the Lake Superior region, in particular with the Bayfield Sandstone of northern Wisconsin, the Fond du Lac Sandstone in Minnesota, and the Jacobsville Sandstone of northern Michigan, and also with lower and middle Cambrian sediments in Kentucky and Tennessee. However, because there is no evidence of formational breaks within the Mt. Simon, it is retained as a unit in the Croixan Series. The Mt. Simon Sandstone is an important aquifer in northern Illinois, and on several major structures it is used for the storage of natural gas.

**Crane Member**—The Crane Member of the Mt. Simon Sandstone (Templeton, 1950, p. 154), the basal member, is named for Crane School, De Kalb County, 4 miles south of the type section, which is the interval from 3105-3845 feet deep in Wyman No. 1 boring (NE NE SE 35, 41N-5E) (sample set [SS] 1301). It is relatively fine grained, but some of it is medium grained and a few small pebbles are present in places. The lower part is generally shaly, silty, and arkosic. It is 620-740 feet thick, and it has been differentiated in only a few wells in central northern Illinois.

**Kenyon Member**—The Kenyon Member of the Mt. Simon Sandstone (Templeton, 1950, p. 154), which overlies the Crane Member, is named for Kenyon School, De Kalb County, 3.25 miles southeast of the type section, which is the interval from 2975-3105 feet deep (SS 1301) in the same boring as the Crane Member. The Kenyon Member is 34-130 feet thick. Where less than 80 feet thick it consists of coarse-grained sandstone containing small quartz pebbles, but elsewhere it is conglomeratic sandstone interbedded with nonconglomeratic layers.

**Lovell Member**—The Lovell Member of the Mt. Simon Sandstone (Templeton, 1950, p. 155), which overlies the Kenyon Member, is named for Lovell School, De Kalb County, three-fourths of a mile south of the type section, which is the interval from 2850-2975 feet deep (SS 1301) in

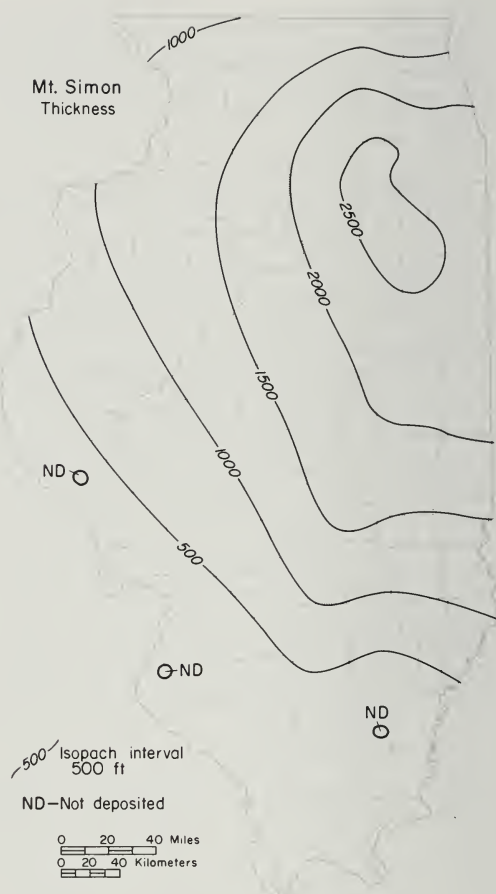


Fig. C-6—Thickness of the Mt. Simon Sandstone.

the same boring as the Crane Member. The Lovell Member is 65-190 feet thick. It is largely fine- to medium-grained sandstone, although it ranges from very fine to very coarse. It is finer grained than the adjacent members.

**Mayfield Member**—The Mayfield Member of the Mt. Simon Sandstone (Templeton, 1950, p. 155), which overlies the Lovell Member, is named for Mayfield Township, De Kalb County, 5 miles west of the type section, which is the interval from 2495-2850 feet deep (SS 1301) in the same boring as the Crane Member. The Mayfield Member is 145-390 feet thick. It is composed of interbedded very coarse-grained conglomeratic sandstone and finer grained nonconglomeratic sandstone.

**Lacey Member**—The Lacey Member of the Mt. Simon Sandstone (Templeton, 1950, p. 155) overlies the Mayfield Member. It is named for Lacey School, De Kalb County, 2.5 miles east of the type section. The member is 1880-2070 feet deep in McQueen No. 1 boring (SW NE NE 27, 42N-3E) (SS 1466). The Lacey Member is 176-230 feet thick and is principally conglomeratic sandstone, although beds of fine-grained sandstone occur in the middle part and locally in the lower part. Beds of red shale are more common in the Lacey and higher members than in the lower members. Only the Lacey and higher members of the Mt. Simon are differentiated in northeastern Illinois (Buschbach, 1964).

**Gunn Member**—The Gunn Member of the Mt. Simon Sandstone (Templeton, 1950, p. 155), which overlies the Lacey Member, is named for Gunn School, De Kalb County, 2.75 miles northwest of the type section. The member is 1648-1880 feet deep (SS 1466) in the same boring as the Lacey Member. The Gunn Member is 130-150 feet thick in the Chicago area, but elsewhere it is 71-260 feet thick. It is a relatively fine-grained member, but the sand ranges from fine to medium grained. A few thin conglomeratic beds are present in some areas.

**Charter Member**—The Charter Member of the Mt. Simon Sandstone (Templeton, 1950, p. 156), the uppermost member, is named for Charter Oak School, De Kalb County, 3.5 miles north of the type section, which is the interval from 1381-1648 feet deep (SS 1466) in the same boring as the Lacey Member. The Charter Member is 145-320 feet thick. It is medium- to fine-grained, partly conglomeratic sandstone with some red micaceous shale at or near the base.

## KNOX DOLOMITE MEGAGROUP

The Knox Dolomite Megagroup (Safford, 1869, p. 151, 158-159; Swann and Willman, 1961, p. 477), named for Knox County, Tennessee, is relatively pure dolomite. The unit underlies the St. Peter Sandstone and overlies either the Potsdam Sandstone Megagroup or, as in much of Illinois, the interbedded sandstone and dolomite that is not included in either the Potsdam or the Knox Megagroups. The Knox Megagroup includes strata of Cambrian (Croixan) and Ordovician (Canadian and Chazyan) age (figs. 14, C-3). It underlies all of Illinois except small areas in northern Illinois where the sub-Tipppecanoe unconformity cuts entirely through the dolomite formations and the St. Peter Sandstone rests on the Franconia Formation or, locally, on the Ironton Sandstone (fig. O-13). Although dominantly dolomite, in the northern part of the state the megagroup contains relatively thin sandstones—the New Richmond and Gunter Sandstones, the Momence Sandstone Member of the Eminence Formation, the Jordan Sandstone, and numerous thin beds in the Shakopee Dolomite (figs. C-3, O-8). The sandstones generally thin southward and disappear near the middle of the state. The megagroup, on the other hand, thickens southward from 300-500 feet in much of northern Illinois to more than 6000 feet in extreme southern Illinois (fig. C-7). The southward thickening of the Knox is related to northward truncation of the upper part of the Shakopee Dolomite and also to inclusion of the Everton Dolomite at the top of the megagroup in the extreme southern part of the state. In addition, the Franconia Formation and the Ironton and Galesville Sandstones grade southward into dolomite, resulting in repeated lowering of the base of the Knox until it reaches the top of



Fig. C-7—Thickness of the Knox Dolomite Megagroup.

the Mt. Simon Sandstone. In the northern part of the state, where the Knox is partly exposed and many wells penetrate the formations, the Knox is differentiated into several formations, which lessens the need to recognize the megagroup. In southern Illinois where the distinguishing characteristics of many formations disappear and the formations cannot be differentiated, the megagroup is more essential. The Knox Dolomite Megagroup is equivalent to the Knox Formation or Knox Group, as it is called in states south and east of Illinois, and to the Arbuckle and Ellenberger Formations or Groups in states to the southwest.

## Eau Claire Formation

The Eau Claire Formation (Ulrich, in Walcott, 1914, p. 354) consists of dolomite and dolomitic sandstone, siltstone, and shale overlying the relatively clean sandstone of the Mt. Simon Sandstone and underlying the clean sandstone of the Galesville Sandstone. It is named for



Fig. C-8—Thickness of the Eau Claire Formation.

Eau Claire, Eau Claire County, Wisconsin, where the type section consists of 100 feet of thin-bedded, partly shaly, fossiliferous sandstone (fig. C-1C). The Eau Claire Formation underlies all of Illinois, but it is not exposed. It ranges from less than 300 feet thick in the western part of the state to more than 1000 feet in the southeast (fig. C-8). In northern and western Illinois the Eau Claire Formation is dominantly dolomitic, fine- to medium-grained, gray sandstone, but it includes shaly siltstone and silty, sandy, glauconitic, brownish gray dolomite (fig. C-9). In central and eastern Illinois it is dominantly dolomitic, orange to pinkish gray siltstone and green, gray, or red shale, but it includes light gray, glauconitic, partly oolitic limestone and dolomite. In southern Illinois it is dominantly fine-grained, gray dolomite or limestone but it includes some beds of siltstone, shale, and sandstone. Some beds of the Eau Claire are oolitic, others are brecciated. The base of the Eau Claire is characterized by a "sooty" sandstone in which the sand grains are coated with a fine black powder consisting of pyrite (Workman and Bell, 1948). In northeastern Illinois the Eau Claire Formation is differentiated into three members that have been widely traced throughout the northern half of the state—the Elmhurst Sandstone

Member (at the base), the Lombard Dolomite Member, and the Proviso Siltstone Member (Buschbach, 1964). Some beds in the Eau Claire contain abundant fragments of inarticulate brachiopods and trilobites, which can easily be observed in samples from borings, but the fauna has not been studied in Illinois. The Eau Claire is recognized from Minnesota to Kentucky and Ohio. West of Illinois it is equivalent to the Bonnetterre Formation.

**Elmhurst Sandstone Member**—The Elmhurst Sandstone Member of the Eau Claire Formation (Buschbach, 1964, p. 32), the basal member, is named for Elmhurst, Du Page County, half a mile east of the type section, which is at a depth of 1640-1759 feet in a boring (Wander Co. No. 11, SE NW NE 10, 39N-11E) (SS 15,336). The Elmhurst Member is widely distributed in the northern half of Illinois and is 10-200 feet thick. Most of it is fine- to medium-grained, fossiliferous, gray sandstone that contains various amounts of interbedded gray shale. The basal part contains the sooty zone.

**Lombard Dolomite Member**—The Lombard Dolomite Member of the Eau Claire Formation (Buschbach, 1964, p. 32) overlies the Elmhurst Member and is named for Lombard, Du Page County, 2 miles west of the type section, which is at a depth of 1535-1640 feet (SS 15,336) in the same boring as the Elmhurst Member. The Lombard Member is recognized in northeastern Illinois, where it ranges from a few to 150 feet thick. It consists chiefly of grayish brown, glauconitic, partly sandy dolomite containing beds of greenish gray shale. It contains beds of limestone in Kane and Du Page Counties. Northward and westward it grades to sandstone, and southward it becomes more shaly.

**Proviso Siltstone Member**—The Proviso Siltstone Member of the Eau Claire Formation (Buschbach, 1964, p. 32), the uppermost member, is named for Proviso Township, Cook County, 2 miles east of the type section, which is at a depth of 1385-1535 feet (SS 15,336) in the same boring as the Elmhurst Member. It is widely present in the northern part of Illinois. It is 150-300 feet thick, except near the northern boundary of the state where it grades to sandstone and is not differentiated. It is dominantly dolomitic, sandy, firm, orange to pinkish gray, feldspathic, slightly glauconitic siltstone that commonly contains beds of greenish gray, pink, or red shale. Along its northern limit it is sandstone and shale, but southward it becomes more dolomitic. The upper few to 40 feet consists of fine-grained dolomitic sandstone or sandy dolomite that is transitional to the overlying Galesville Sandstone.

## Galesville Sandstone

The Galesville Sandstone (Trowbridge and Atwater, 1934, p. 45), a clean, unfossiliferous sandstone, is named for Galesville, Trempealeau County, Wisconsin, where the type section is in an exposure on Beaver Creek. The section exposes poorly sorted, fossiliferous sandstone of the Ironton Formation overlying 88 feet of the Galesville Sandstone, which in turn lies on fossiliferous sandstone and shale of the Eau Claire Formation. In earlier reports Galesville and Ironton Sandstones were called the Dresbach Sandstone. In many borings in Illinois the Galesville is not easily distinguished from the overlying Ironton Sandstone, and their combined thickness is shown in figure C-10. The Galesville occurs throughout the northern half of Illinois but is not exposed. It is commonly 40-100 feet thick. At its southern margin, the Galesville grades laterally through a zone of dolomitic sandstone about 50 miles wide to nonsandy dolomite of the Knox Megagroup. The name "Galesville" is applied as far south as the sandy zone can be identified, at which place the for-

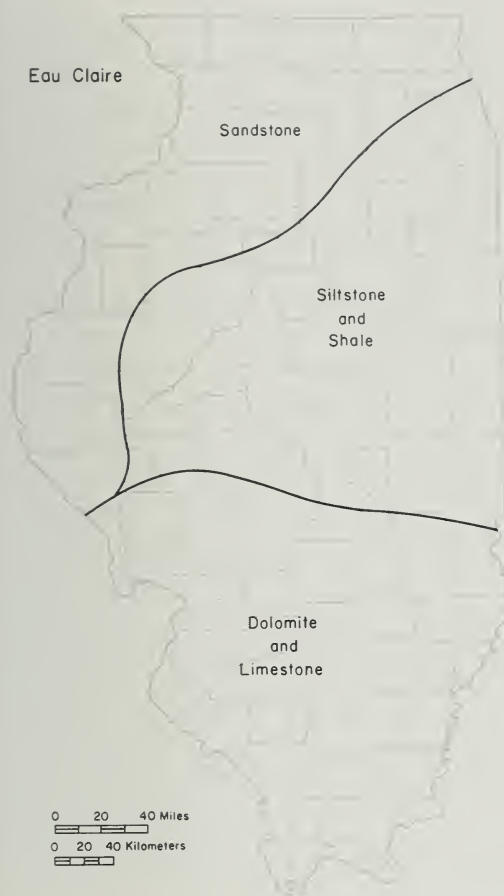


Fig. C-9—Dominant rock types in the Eau Claire Formation.

mation is terminated by vertical cut-off. The Galesville Sandstone consists of white to light buff, clean to locally silty, fine-grained, moderately well sorted, friable, and generally nondolomitic sandstone (Buschbach, 1964). Locally, light buff to pink dolomite is a cementing material. From a petrographic study and analysis of sedimentary structures, Emrich (1966) concluded that the Galesville and Ironton Sandstones were derived from pre-existing sedimentary rocks north of Illinois and were deposited on a broad, shallow shelf. The Galesville appears to be conformable with both the overlying and underlying formations. It is also recognized in Iowa, Minnesota, Michigan, and Indiana. It is not traced directly to the Missouri outcrop region, but it probably is equivalent to the upper carbonate beds of the Bonneterre Formation. The Galesville and the overlying Ironton Sandstone form an important aquifer in northern Illinois.

### Franconian Stage

The Franconian Stage (Howell et al., 1944, chart 1) includes the strata from the *Elvinia*

Zone (at the base) to the top of the *Dikelocephalus postrectus* Zone and is based on the type section of the Franconia Formation at Franconia, Chisago County, Minnesota. Some stratigraphers prefer to place the top of the stage lower in the Franconia, at the top of the *Ptychaspis-Prosaukia* Zone of Bell et al. (1956)—the *Prosaukia* Zone of Lochman-Balk and Wilson (1958). These faunal zones have not been differentiated in Illinois, but the Ironton and Franconia Formations are at least approximately equivalent to the type Franconia Formation and are included in the Franconian Stage.

### Ironton Sandstone

The Ironton Sandstone (Thwaites, 1923, p. 93-94), a relatively coarse-grained sandstone overlying the finer grained Galesville Sandstone and underlying the glauconitic, argillaceous sandstone of the Franconia Formation, is named for Ironton, Sauk County, Wisconsin, where it consists of a few feet of hard, calcareous, coarse-grained sandstone classified as the basal member of the Franconia Formation. In Illinois, a much thicker coarse-grained sandstone at this position, previously included in the Dresbach Sandstone, was correlated with the Ironton Member of the Franconia, but it later was made a separate formation (fig. C-5). The Ironton Sandstone, like the Galesville (fig. C-10), occurs throughout the northern half of Illinois and is not exposed. The Ironton is commonly 50-100 feet thick, but it is somewhat thinner in northwestern Illinois. Near the northern boundary of Illinois, the Ironton is medium-grained, poorly sorted, white sandstone with coarse-grained beds near the top. It

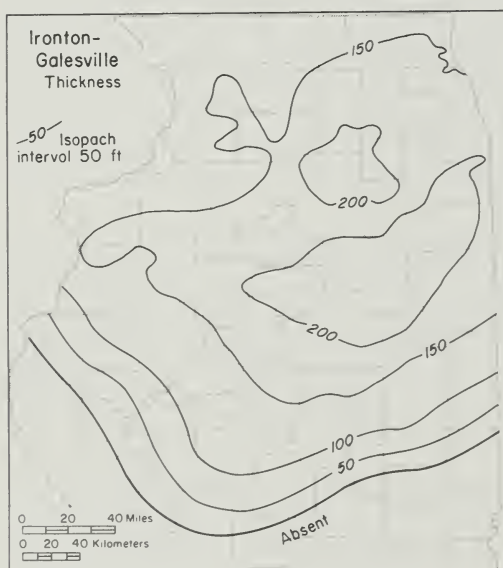


Fig. C-10—Thickness of the Ironton and Galesville Sandstones.

generally contains light pinkish buff dolomite as a cementing material and as pebbles in conglomeratic layers (fig. C-1D). Farther south it is more dolomitic. At its southern margin it grades into sandy dolomite, and, like the Galesville Sandstone, is terminated by vertical cut-off. The Ironton Sandstone is coarser grained than sandstones in the formations above and below, and it lacks the clay and glauconite commonly associated with the overlying Franconia (Buschbach, 1964). Variations in grain size and dolomite content serve to divide the Ironton into four members: the Buelter Member (at the base) is medium-grained sandstone; the Fox Valley Member is medium- to coarse-grained dolomitic sandstone; the Marywood Member is finer grained and less dolomitic sandstone; and the Mooseheart Member (at the top) is medium- to coarse-grained dolomitic sandstone. The petrographic characteristics of the Ironton Sandstone have been described by Emrich (1966). In the outcrop region in Wisconsin, the Ironton is fossiliferous and contains the *Elvinia* Zone, which marks the base of the Franconian Stage. Worm borings are common in some of the dolomitic beds, which are called wormstone beds. The Ironton Sandstone is conformable with the formations above and below. It is also present in Minnesota, Michigan, and Indiana but is an undifferentiated part of the Galesville Sandstone in those areas. It is correlated with the lower part of the Davis Formation in Missouri.

**Buelter Member**—The Buelter Member of the Ironton Sandstone (Buschbach, 1964, p. 36), the basal member, is named for Buelter School, Kane County, 2 miles east of the type section, which is at a depth of 1180-1230 feet in Batavia city well No. 3 (SE SW NE 22, 39N-8E) (SS 6901). It is widely present in northern Illinois, where it is 20-80 feet thick. It is dominantly medium-grained, moderately well sorted, rarely dolomitic sandstone. The contact with the underlying fine-grained, well sorted sandstone of the Galesville is generally sharp.

**Fox Valley Member**—The Fox Valley Member of the Ironton Sandstone (Buschbach, 1964, p. 37), which overlies the Buelter Member, is named for the Fox River Valley, where the type section occurs at a depth of 1168-1180 feet in the same well as the Buelter type section. The Fox Valley Member is commonly 10-25 feet thick. It consists of poorly sorted medium- to coarse-grained sandstone that is consistently dolomitic. Dolomite occurs as cementing material and as stringers of light pink to buff sandy dolomite interbedded with the sandstone. Brown spheroids and oolites are present in the dolomite.

**Marywood Member**—The Marywood Member of the Ironton Sandstone (Buschbach, 1964, p. 37), which overlies the Fox Valley Member, is named for Marywood, Kane County, 4 miles south of the type section, which is at a depth of 1120-1168 feet in the same well as the Buelter type section. The Marywood Member appears to be as widespread as the other members, but in some areas it is not readily separated from the units above and below. It is 10-50 feet thick and consists of sandstone that is finer grained and less dolomitic than the units above and below.

**Mooseheart Member**—The Mooseheart Member of the Ironton Sandstone (Buschbach, 1964, p. 37), the uppermost member, is named for a Kane County lake, Mooseheart Lake, 2 miles southwest of the type section, which is at a depth of 1092-1120 feet in the same well as the Buelter type section. The Mooseheart Member is 20-60 feet thick. It consists of poorly sorted, medium- to coarse-grained dolomitic sandstone. Coarse grains of glauconite occur in the upper beds.

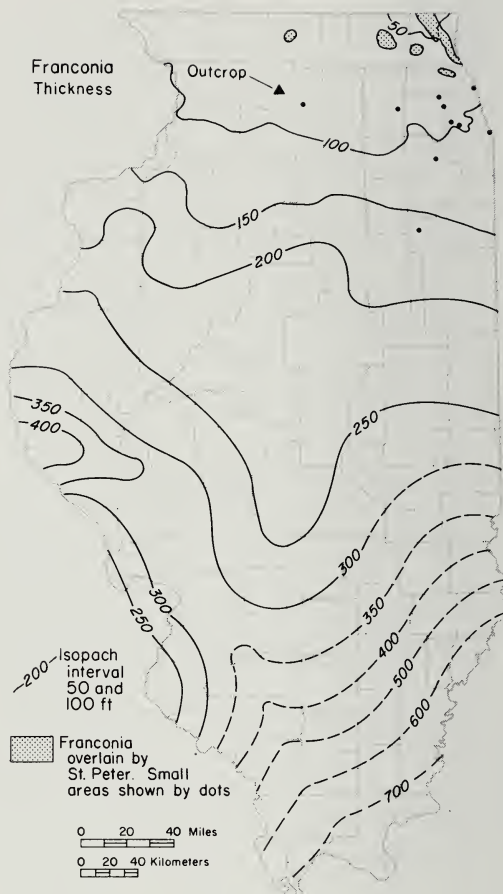


Fig. C-11—Thickness of the Franconia Formation.

## Franconia Formation

The Franconia Formation (Berkey, 1897, p. 373) consists of glauconitic, argillaceous sandstone and dolomite underlying the relatively pure Potosi Dolomite. It is named for Franconia, Chisago County, Minnesota, where the type section consists of 100 feet of sandstone and shale. In Illinois, these strata were originally differentiated as Mazomanie by Thwaites (1927) and first assigned to the Franconia by Workman (1935). The Franconia Formation underlies all of Illinois but is exposed in only one locality, half a mile east of Oregon, Ogle County, where the upper 30 feet, overlain by the Potosi Dolomite, is poorly exposed. This is the oldest formation exposed in Illinois, although it and older Cambrian strata may underlie the glacial drift along the south side of the Sandwich Fault Zone in Ogle, Lee, or De Kalb Counties. The Franconia Formation thickens southward from about 50 feet near the northern boundary of Illinois to probably 500-700 feet in the southern part of the state (fig. C-11). In extreme northern Illinois, the Franconia consists largely of gray to pink, glauconitic, silty, argillaceous, fine-grained, dolomitic sandstone that contains various amounts of red and green shale. Raasch reported several

species of trilobites, oboloid brachiopods, and worm casts in the exposure at Oregon (Willman and Templeton, 1951). Southward from that area the lowermost part of the Franconia becomes increasingly shaly (Davis Member), and the uppermost part grades to silty and sandy dolomite (Derby-Doerun Member). In north-central Illinois these two units are separated by a wedge of fine-grained, glauconitic, dolomitic sandstone similar to the strata that compose the entire Franconia of extreme northern Illinois. In the central and southern parts of the state, the glauconitic sandstone is absent, and the silty, shaly sandstone of the Davis is directly overlain by the relatively pure dolomite of the Derby-Doerun. Because of its diminishing amounts of sand, shale, and glauconite, the upper part of the Franconia is difficult to differentiate from the overlying Potosi Dolomite, and the base of the Knox Dolomite Megagroup steps down to include the Derby-Doerun Member. In Illinois the Franconia is conformable with the overlying and underlying formations. It is also recognized in Wisconsin, Iowa, Michigan, Indiana, and Kentucky, and it is equivalent to the Elvins Group in Missouri.

**Davis Member**—The Davis Member of the Franconia Formation (Buckley, 1907; 1909, p. 33), the basal member, is named for outcrops on Davis Creek, St. Francois County, southeast Missouri. It is recognized as a shaly sandstone unit at the base of the Franconia throughout all of Illinois except the extreme north, where the entire Franconia is represented by shaly and glauconitic sandstone, and in the southeast (Lawrence and Hamilton Counties), where the unit appears to have graded to dolomite and is included in the Knox Megagroup. It ranges from a few feet thick in the north to about 100 feet in the south. It grades from shaly sandstone in the north to silty, sandy, argillaceous dolomite in the south. The member is characterized by green, gray, or red shale partings and by flat-pebble conglomerate.

**Derby-Doerun Member**—The Derby-Doerun Member of the Franconia Formation (Buckley, 1907; 1909, p. 44) overlies the Davis Member in central and southern Illinois. In north-central Illinois it is the upper part of the Franconia where the lower part of the Franconia is fine-grained glauconitic sandstone. The Derby and the overlying Doerun were named separately for exposures in the vicinity of mines operated by the Derby Lead Company and the Doerun Lead Company near Elvins, St. Francois County, Missouri. Their similar lithology and a conformable relationship resulted in their being combined as a formation with a hyphenated name (Hayes and Knight, 1961). In north-central Illinois the Derby-Doerun is silty argillaceous dolomite. Farther south it becomes quite pure, except for a thin zone at the top that is slightly sandy, argillaceous, and glauconitic. The member is about 20 feet thick in the north and it thickens to probably more than 500 feet in the southeast. It is included in the Knox Dolomite Megagroup.

## Trempealeuan Stage

The Trempealeuan Stage (Howell et al., 1944, chart 1) consists of the strata from the base of the *Platycolpus-Scoevogyra* Zone to the top of the *Plethopeltis* Zone as they are represented in the type section of the Trempealeu Formation (now called the St. Lawrence Formation) at Trempealeau, Trempealeau County, Wisconsin. However, more recent work (Raasch, 1951; Lochman-Balk and Wilson, 1958) favors placing the base of the Trempealeuan somewhat lower—at the base

of the *Saukia* Zone in the Franconia Formation. As the fossil zones have not been recognized in Illinois, the exact position of the base of the Trempealeuan Stage is uncertain and is placed at the top of the Franconia Formation. The Potosi, Eminence, and Jordan Formations are included in the Trempealeuan Stage.

## Potosi Dolomite

The Potosi Dolomite (Winslow, 1894, p. 331, 351, 355), named for Potosi, Washington County, Missouri, is a relatively pure dolomite overlying the sandstone and sandy dolomite of the Franconia Formation and underlying the sandy Eminence Formation. In northern Illinois it was called Trempealeau (Workman and Bell, 1948) until the type Trempealeau was renamed "St. Lawrence" and "Trempealeuan" was used for the stage name. Potosi was then extended to northern Illinois (Buschbach, 1964). The Potosi Dolomite underlies essentially all of Illinois, except in parts of northern Illinois where it was truncated by the sub-Tippecanoe unconformity. It is exposed in the



Fig. C-12—Thickness of the Potosi Dolomite.

Oregon and Ashton areas in Ogle and Lee Counties (Willman and Templeton, 1951) (fig. C-1A), where it is generally overlain by the St. Peter Sandstone. The exception is one exposure in Lee County, 4 miles south of Rochelle, Ogle County, where it is overlain by the Oneota Dolomite (fig. C-1B). The Potosi ranges from 100 feet thick in northern Illinois to more than 300 feet in southern Illinois (fig. C-12). It consists of finely crystalline, pure to slightly argillaceous, brown to pinkish gray dolomite that is very slightly glauconitic at the top and glauconitic and sandy at the base. Drusy quartz covers the surfaces of small cavities in most areas and characterizes the formation in both outcrops and well samples. The Potosi contains algal domes and rare trilobite and gastropod remains. In the southern two-thirds of the state the Potosi is conformable with the Franconia below and the Eminence above, but in wide areas in northern Illinois it is unconformably overlain by the St. Peter Sandstone. Locally over the Ashton Arch the Eminence is absent and the Oneota overlies the Potosi. The Potosi is equivalent to the St. Lawrence Dolomite in Wisconsin (Ostrom, 1967), Michigan (Catacosinos, 1973), and Minnesota (Stauffer and Thiel, 1941) and to the Trempealeau Dolomite in Indiana (Gutstadt, 1958a).

## Eminence Formation

The Eminence Formation (Buckley, 1908, p. 286), a sandy dolomite overlying the Potosi Formation, is named for Eminence, Shannon County, Missouri. It was traced into central Illinois by Workman and Bell (1948) and extended by Buschbach (1964) to northeastern Illinois, where it previously had been included in the Trempealeau or the Oneota. The formation underlies most of Illinois, except the northern part, where it was truncated by the sub-Tipppecanoe unconformity at the base of the St. Peter Sandstone. Over the Ashton Arch it appears to thin to a feather edge. It is not exposed in Illinois. The Eminence is 50-250 feet thick in the areas where it is overlain by the Gunter Sandstone or the Oneota Dolomite (fig. C-13). It consists of light gray to brown or pink, sandy, fine- to medium-grained dolomite that contains oolitic chert and thin beds of sandstone. The formation contains less drusy quartz than the Potosi and is sandier and finer grained than the Oneota. In the southern third of Illinois the Eminence loses much of its sand and becomes an undifferentiated part of the Knox Megagroup. Sandstone at the base of the formation is differentiated as the Momence Sandstone Member. The irregular distribution of the Momence and the overlying Gunter Sandstone suggests that the formation may be bounded by minor unconformities, but otherwise the relations appear to be conformable. Except around the margins, sedimentation in the Illinois Basin was probably essentially continuous from Cambrian into Ordovician time. In the extreme northwestern part of Illinois, the Eminence Formation grades laterally into the Jordan Sandstone.

**Momence Sandstone Member**—The Momence Sandstone Member of the Eminence Formation (Buschbach, 1964, p. 41) is named for Momence, Kankakee County, just east of the type section, which is at a depth of 1650-1660 feet in the Hughes Oil Company No. 1 Parish boring (NW NW SW 24, 31N-13E) (SS 997). It is the only member differentiated in the Eminence Formation and occurs at the base. The Mo-



Fig. C-13—Thickness of the Eminence Formation.

mence Member varies from 0-15 feet thick but is somewhat discontinuous. It consists of light gray, dolomitic, poorly sorted sandstone, and in places contains interbedded green and gray sandy shale.

## Jordan Sandstone

The Jordan Sandstone (A. Winchell, 1872), the uppermost Cambrian formation in the extreme northwestern part of Illinois, is named for Jordan, Scott County, Minnesota, where it is exposed in quarries and outcrops along Sand Creek (N.H. Winchell, 1874, p. 149). It is not exposed in Illinois but is a few to 75 feet thick in wells in Jo Daviess and Carroll Counties. In exposures along the Mississippi River a short distance northwest of Illinois in Iowa, Minnesota, and Wisconsin, the formation is a white to yellowish gray, partly iron-stained sandstone that is medium to fine grained at its base. In some places the upper part is coarse to very coarse grained (Stauffer and Thiel, 1941). It varies from thin to thick bedded. Cross bedding is common. Fossils are abundant in some beds in the outcrop area. East and south of Jo Daviess and Carroll Counties the Jordan Sandstone grades laterally to the Eminence Formation.

## ORDOVICIAN SYSTEM

*H. B. Willman and T. C. Buschbach*

The Ordovician System (Lapworth, 1879, p. 12-14) underlies all of Illinois except a few areas in the northern part of the state where it has been eroded and Cambrian rocks are at the surface (fig. O-1). The name "Ordovician" is derived from *Ordovices*, the Roman name for a people who inhabited Wales, where these rocks are well exposed. Before "Ordovician" was introduced, these strata were included in the Silurian System, and they were called Lower Silurian in the early reports on Illinois stratigraphy.

Ordovician rocks are widely exposed in northern Illinois, particularly along the upper Illinois Valley, the Rock Valley, the Pecatonica Valley, and the Upper Mississippi Valley and its tributaries north of Savanna. Elsewhere in Illinois they are exposed only along truncated anticlines—in Calhoun and Jersey Counties, Monroe County, and Alexander County. Typical exposures are shown in figure O-2.

The Ordovician System, where overlain by the Silurian System, ranges from 700 feet thick in extreme northeastern Illinois to more than 5000 feet in southern Illinois (fig. O-1). The variations in thickness are related to major unconformities that occur at the top and within the Ordovician System and to original southward thickening of many of the formations. The structure of the system is shown by the map of the structure of the top of the Galena Group (fig. O-3).

The Ordovician System is subdivided into three series based on faunal correlations and on lithologic tracing from Illinois to their type regions. The Canadian Series and the Champlainian Series have been traced to New York State, and the Cincinnati Series to Cincinnati, Ohio.

The Ordovician System in Illinois is dominantly dolomite and limestone. It is differentiated into 26 formations and 66 members (fig. O-4). Four of the formations are dominantly sandstone, four are shale, and 18 are limestone or dolomite. Most of the formations extend throughout the state and many throughout the Mississippi Valley. Some even have lithologic continuity eastward to New York and Virginia, southward to Tennessee, westward to Colorado, and northward to

northern Michigan and Ontario (Templeton and Willman, 1963).

The Ordovician System is separated from the systems above and below it by unconformities, but both unconformities are difficult to recognize in parts of the state, particularly in the subsurface. In the southern part of Illinois, the lowermost Ordovician dolomites are not readily separable from the Cambrian dolomites that underlie them, especially in areas where the basal Ordovician Gunter Sandstone is missing. The upper Ordovician (Cincinnati) shales in some areas contain dolomitic siltstones that are not readily separable from similar early Silurian sediments that fill erosional channels cut into the Cincinnati strata.

Within the Ordovician System other unconformities occur, particularly at the base of the Champlainian (the sub-Tippecanoe unconformity) and the base of the Cincinnati Series. Within the Champlainian Series, a lesser but widespread unconformity occurs at the base of the Trentonian Stage. The Champlainian rocks contain numerous minor diastems that reflect interruptions in sedimentation but do not indicate withdrawal of the sea. Corrosion surfaces, which truncate only a few inches of strata, represent temporary cessation of carbonate deposition and solution of the sea floor. Current-produced features include wavy scour surfaces, which generally have a relief of less than 6 inches, and giant ripple marks.

During most of Ordovician time, Illinois was in a broad sea, far from the shores and from the sources of clastic sediments. Most of the sediments were moderately deep-water, fine-grained carbonate. During mid-Champlainian Blackriveran time, shallow-water argillaceous carbonates and evaporites (Joachim, Glenwood) were deposited; later, during Trentonian time, coarse calcarenites (Kimmswick) accumulated in the southern part of Illinois. The sand in the Canadian and early Champlainian sandstones came from the north. Only during Cincinnati time, when large deltas were being built in the Appalachian region, did clay and silt from the east dominate the clastic sediments in Illinois.

During Canadian time the sea covered the entire state, and sedimentation was essentially

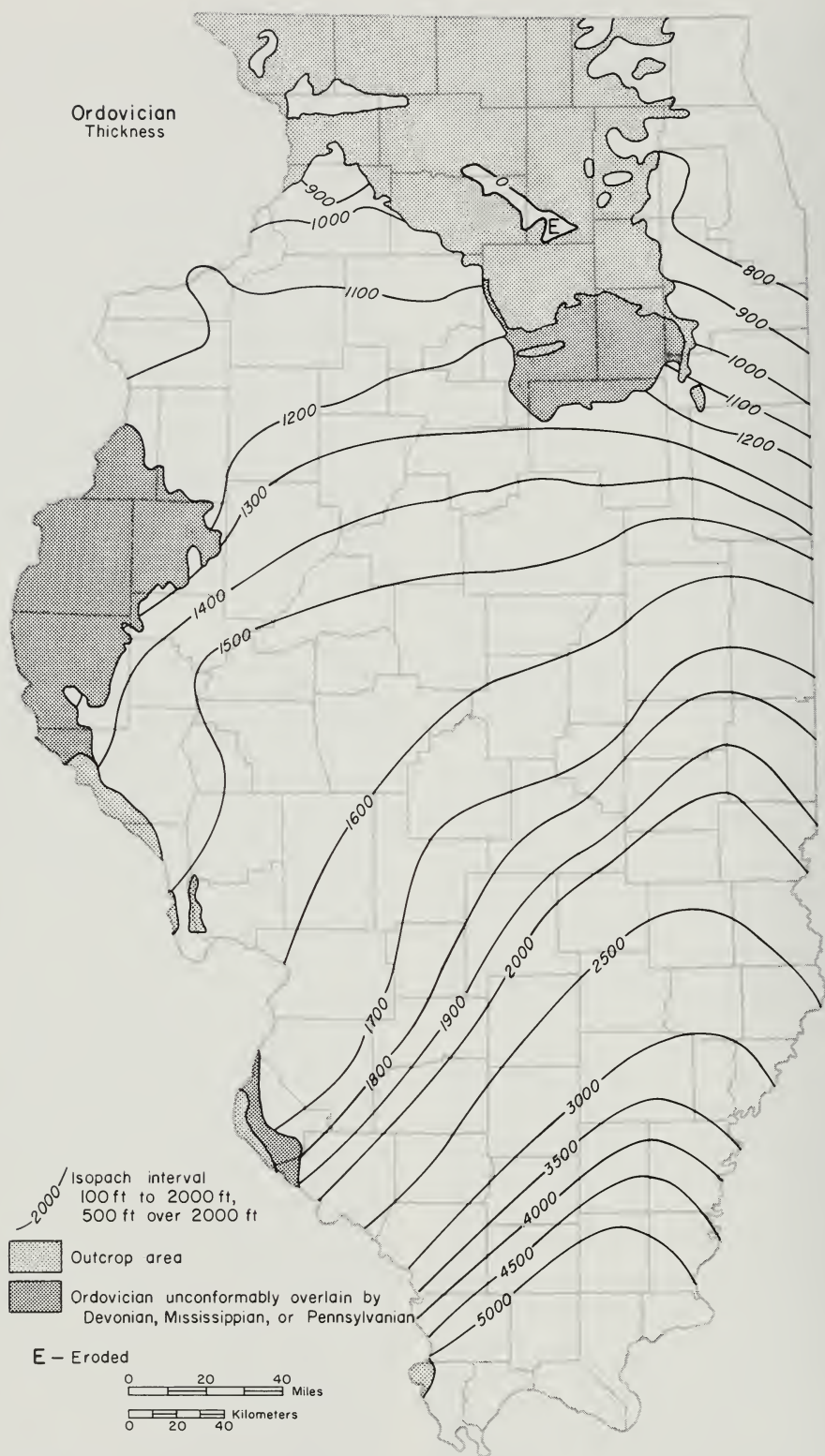


Fig. O-1—Thickness of the Ordovician System.

similar to that of the Cambrian. The Canadian sediments were deeply eroded before the early Champlainian (Chazyan) sediments—largely dolomite, sandy dolomite, and sandstone—were deposited in Illinois. These sediments have much the same character as the Canadian rocks, but in Illinois they were eroded from all except the extreme southwestern part of the state before St. Peter deposition. Their composition suggests they could originally have been as extensive as the Canadian sediments.

The St. Peter Sandstone, at the base of the Champlainian Series in most of Illinois, is an unusually extensive, very pure, uniformly fine-grained, and well sorted quartz sandstone, which appears to have been deposited by a sea advancing northward across the Illinois Basin (Dapples, 1955). South of Illinois it grades into sandy carbonates. Across north-central Illinois the final episode of St. Peter deposition was a broad, east-west, offshore bar of medium-grained sandstone (fig. O-16). North of the bar, and partly contemporaneous with it, the poorly sorted sandstone, impure dolomite, and shale of the Glenwood accumulated, and south of the bar the shaly limestone of the Dutchtown and the sandy and argillaceous dolomite of the Joachim were deposited. These impure sediments join the St. Peter to form the Ancell Group.

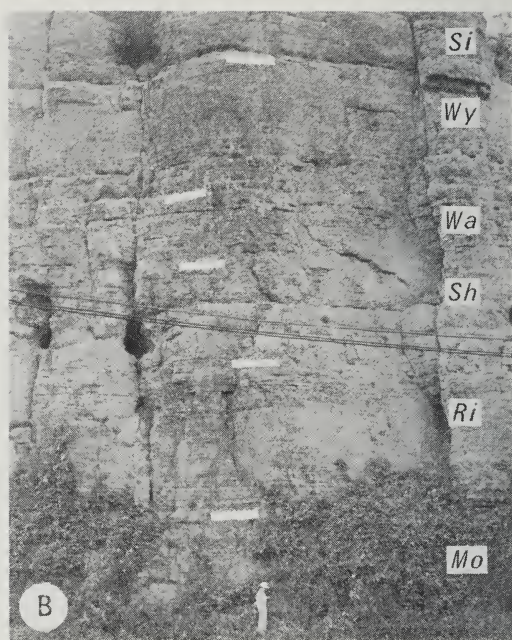
In the Champlainian Series overlying the Ancell, dominantly carbonate rocks are characterized by the persistence of thin units that are identified by relative purity, texture, bentonite beds, and fossils. The argillaceous materials in the Champlainian carbonate rocks in northern Illinois came largely from a northerly source, as is shown by the gradual change in Trentonian rocks from nearly pure carbonate in Illinois to calcareous shale at the northern margin in Minnesota (fig. O-23). The thin shale, sandstone, and siltstone beds in the Blackriveran and lower Trentonian rocks in southwestern Illinois thicken onto the Ozarks, which the overlapping relations of the basal Trentonian strata show were at least intermittently above sea level. The red-brown shales in the Guttenberg Formation thicken to the south in Illinois and the red color may be from the residuum on Cambrian and early Ordovician carbonate rocks in the Ozarks. Although the amount of shale also increases northward from northern Illinois, the red color does not extend far north of the state boundary.

Seven thin beds of bentonite are widely present in the Ordovician section in Illinois,

most of them in the Champlainian Series. Bentonites have been found locally at several other horizons, and others may occur at distinctive, smooth-surfaced bedding planes like those commonly associated with bentonites. Although the bentonites in Illinois are generally less than an inch thick, a few, possibly thickened locally by squeezing, are 3 or 4 inches thick. Most of them are correlated with much thicker beds in Kentucky, Tennessee, and Virginia (Templeton and Willman, 1963).

The rocks of the Canadian Series contain few fossils, but the Champlainian and Cincinnati rocks have large faunas, and fossils are abundant in many beds (fig. O-5). An occasional high-spined gastropod is the most prevalent invertebrate fossil found in the Canadian rocks, but algal domes are common, particularly in the Shakopee Dolomite. In the Champlainian Series the Chazyan strata and the Ancell Group strata have few fossils other than worm borings, except in the Dutchtown, which is not exposed in Illinois. The Platteville and Galena Groups contain a variety of fossils, among which brachiopods, bryozoans, gastropods, and corals are most abundant. Crinoidal debris is abundant in some beds, particularly in southern Illinois. Pelecypods and trilobites are common in a few beds, and conodonts are numerous in the limestones. Fucoids of several types, possibly impressions of marine plants, are abundant and widely distributed in many beds. Several faunal zones based on abundance of one or more species of invertebrates are recognized (fig. O-24) and are widely useful for identification of the formations. The base of the Trentonian rocks is well defined by an abundance of several species that appear for the first time.

In the Cincinnati strata, brachiopods and many species of bryozoans are abundant in most limestones and calcareous shales. Fossils are not common, however, in the very argillaceous limestone, the brown shales and siltstones, or the light greenish gray shales. One to three beds at or near the base of the Scales Shale and another bed 60-70 feet above the base contain a distinctive fauna of small fossils, mostly gastropods and pelecypods less than a quarter of an inch in greatest dimension. These beds are called depauperate beds, and the intervals in which they occur depauperate zones. The beds are mainly phosphatic and pyritic and are generally only an inch or two thick, although locally they are as much as a foot thick. The lower zone is very persistent, but the upper has been found only in northeastern and central Illinois.



## CANADIAN SERIES

The Canadian Series (Dana, 1874, p. 214), named for exposures in eastern Canada, unconformably overlies Cambrian dolomite (Eminence) throughout most of Illinois, but in northwestern Illinois it overlies Cambrian sandstone (Jordan). The series, in turn, is overlain unconformably by Champlainian sandstone (St. Peter), except in the southernmost part of the state where it is overlain by sandy dolomite (Everton) (fig. O-4). The lower Ordovician strata in Illinois have been included in the Canadian Series since 1963 (Templeton and Willman). They were called the Lower Magnesian (Owen, 1840) until the early 1900s, at which time they were named the Prairie du Chien or Lower Ordovician Series (fig. O-6). The Canadian Series is represented in Illinois by the Prairie du Chien Group, which chiefly consists of as much as 2500 feet of cherty dolomite that contains some beds of sandstone. Canadian strata contain few megafossils, and preservation of the fossils is generally poor. Gastropods, cephalopods, and algal mounds are the most common evidences of the life from the Canadian seas.

### Prairie du Chien Group

The Prairie du Chien Group (Bain, 1906, p. 18) includes all strata of Canadian age in Illinois. The group is named for exposures near Prairie du Chien, Crawford County, Wisconsin, where it consists of 200-300 feet of dolomite and sandstone. The group is present throughout much of Illinois (fig. O-7). It is almost entirely absent in the northern two tiers of counties and is missing locally in the rest of the northern third of the state, having been removed by solution and erosion before the St. Peter Sandstone was deposited. It is also absent in areas where Cambrian rocks crop out near the Sandwich Fault Zone, on the Ashton Arch, and on the Oregon Anticline. Prairie du Chien strata crop out along the Fox and Rock Valleys, mainly just south

of the Sandwich Fault Zone. The group thickens southward, chiefly by the addition of younger beds at the top, to about 800 feet along a line between Edgar and Monroe Counties. South of there, the base of the Prairie du Chien cannot be picked with confidence, but the group appears to thicken to at least 2500 feet. In the southern part of the state, Prairie du Chien strata combine with the underlying Cambrian carbonates to form the Knox Dolomite Megagroup. The Prairie du Chien Group consists of cherty dolomite with some interbedded sandstone. It is subdivided into the Gunter Sandstone (at the base), the Oneota Dolomite, the New Richmond Sandstone, and the Shakopee Dolomite (fig. O-8). The Prairie du Chien Group is equivalent to Beekmantown strata in Ohio, upper Knox in Tennessee, and upper Arbuckle in Oklahoma.

### Gunter Sandstone

The Gunter Sandstone (Ball and Smith, 1903, p. 26) is named for the now abandoned Gunter post office in Miller County, central Missouri, where it is 2.5-18 feet thick in exposures along the Osage River. It is absent in outcrops of lower Prairie du Chien strata in Lee and Ogle Counties, Illinois. In subsurface, the Gunter is commonly a few to 20 feet thick and has a widespread but patchy distribution (fig. O-9). It is continuous and 10-25 feet thick between the centers of La Salle and McLean Counties in north-central Illinois. The Gunter consists of medium- to fine-grained, moderately sorted, subrounded quartz grains. It contains thin beds of light gray, fine-grained dolomite and small amounts of green shale. Sharp contacts and irregular distribution of the sandstone suggest unconformities at its top and bottom. The Gunter is tentatively correlated with the Rose Run Sandstone at the base of the upper Knox in eastern Ohio and eastern Kentucky.

### Oneota Dolomite

The Oneota Dolomite (McGee, 1891, p. 331-333) is named for exposures along the Oneota River (now Upper Iowa River), Allamakee County, northeastern Iowa. In Illinois it is exposed in quarries and ravines along the Ashton Arch near the Fox and Rock Rivers (Willman and Templeton, 1951). The Oneota underlies all of Illinois

Fig. O-2—Exposures of Ordovician rocks.

- A—St. Peter Sandstone in Starved Rock along the Illinois River in Starved Rock State Park, 4 miles south-east of La Salle, La Salle County.
- B—Type section of the Dunleith Formation showing the Mortimer (Mo), Rivoli (Ri), Sherwood (Sh), Wall (Wa), and Wyota (Wy) Members overlain by the Sinsinawa Member (Si) of the Wise Lake Formation at East Dubuque, Jo Daviess County (Templeton and Willman, 1963, geol. sec. 28, p. 238).
- C—Massive Wise Lake Formation overlying the thinner bedded Dunleith Formation, which contains lenses and beds of white chert, in a quarry on the south side of Freeport, Stephenson County.
- D—Relatively thin-bedded Platteville Limestone Group showing the Nachusa (N), Grand Detour (GD), and Mifflin (M) Formations overlying the thick-bedded Joachim Dolomite (J) in a quarry at West Point Landing, Calhoun County (Templeton and Willman, 1963, geol. sec. 11, p. 228).
- E—Massive Oneota Dolomite containing a large algal growth; in a quarry in Lee County, 6 miles south of Rochelle, Ogle County.
- F—Thin-bedded dolomite of the Quimbys Mill Formation overlying massive dolomite of the Nachusa Formation in a quarry on River Street in Dixon, Lee County.

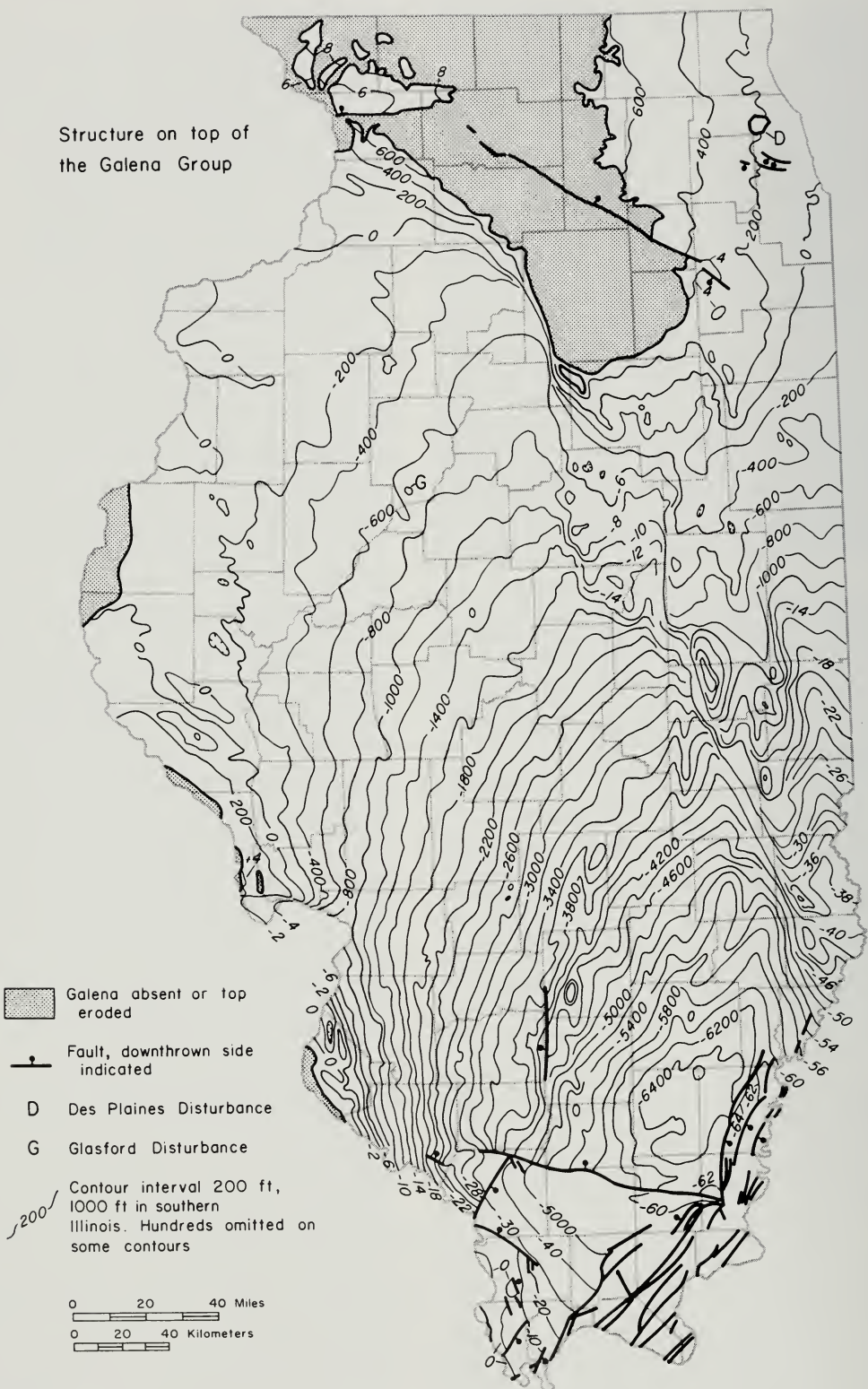


Fig. O-3—Structure of the top of the Galena Group (after Bristol and Buschbach, 1973).

SERIES	STAGE	SEQUENCE	MEGA-GROUP	GROUP	SUB-GROUP	FORMATION	MEMBER	FORMATION	MEMBER
CINCINNATIAN	RICHMONDIAN	↑	Huron			GENERAL		EXTREME	SOUTHWEST
	MAYS. EDENIAN			Maquoketa		Nedo		Girardeau Ls.	
						Brainard Sh.			
						Fort Atkinson Ls.			
						Scales Sh.	Clermont Sh. Elgin Sh.	Scoles Sh.	Orchard Creek Sh. Thebes Ss.
						Cope Ls.		Cope Ls.	
						Dubuque	NORTH	SOUTH	
			(NORTH) (SOUTH)			Wise Lake	Stewartville Sinsinawa	Wise Lake	
				Galena	Kimmswick	Dunleith	Wyoto Woll Sherwood Rivoli Mortimer Fairplay Eagle Point Beecher St. James Buckhorn	Dunleith	New London Moredock Eagle Point Beecher St. James Buckhorn
					Decorah	Guttenberg	Glenhoyen Garnovillo	Guttenberg	Glenhoyen Gornovillo
								Kings Lake	Tysan Mincke
						Spechts Ferry	Glencoe Costlewood	Spechts Ferry	Glencoe Costlewood
			Ottawa			Quimbys Mill	GENERAL Stowbridge Shullsburg Hazel Green		
						Nochusa	Everett Elm Eldeno		
				Platteville	Plattin	Grand Detour	Forreston Victory Hely Clement Stillmon Walgreen Dement		
						Mifflin	Briton Hazelwood Establishment Briceys Blomeyer		
						Pecotanico	Oglesby Medusa New Glarus Done Chona Hennepin		
			(NORTH)				NORTH	SOUTH	
						Glenwood	Hormony Hill Sh. Loughridge Ss. Daysville Dol. Kingdom Ss.	Jochim Dol.	Metz Motson Defiance Boles Augusto Abernothy
			(SOUTH)	Ancell			Nokomis Ss.	Dutchtown Ls.	Shorpsboro Gordonville
						St. Peter Ss.	GENERAL Storved Rock Ss. Tonti Ss. Kress		
						Everton Dol.			
						Shokopee Dol.			
						New Richmond Ss.			
						Oneota Dol.	Blodgett Arsenal		
						Gunter Ss.			
CANADIAN	CHAZYAN	↓ Sauk							
				Knox					
				Prairie du Chien					

Fig. O-4—Classification of the Ordovician System.

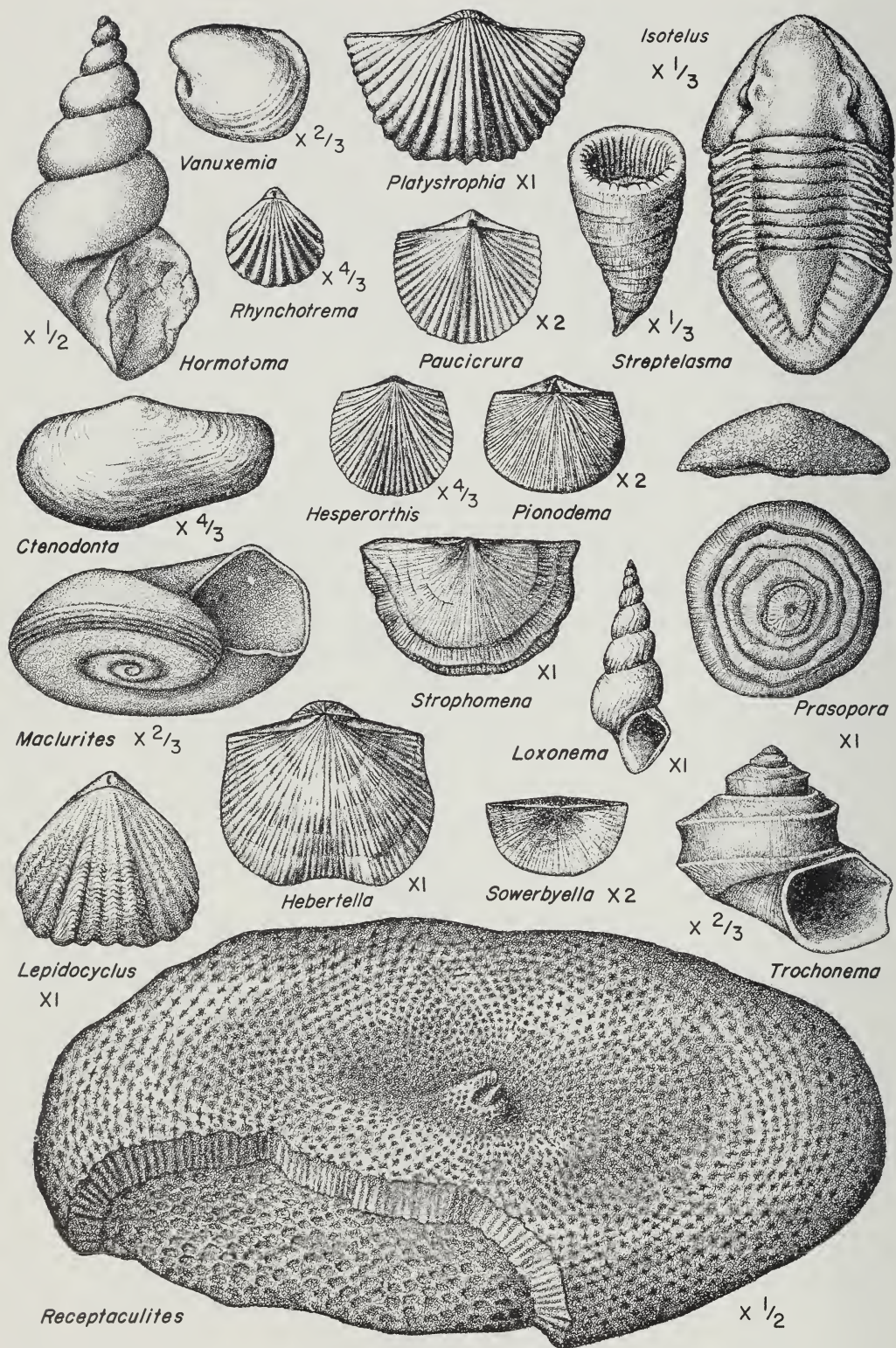


Fig. O-5—Typical Ordovician fossils.

Worthen 1866	Winchell 1874  (Minn.)	Wooster 1882  (Wis.)	Boin 1906		Workmon and Bell 1948		Present, Buschboch 1964			
Lower Mogneson Ls.	Shokopee Ls.	Willow River Beds	Prairie du Chien Group	Shokopee Dol.	Shokopee Dol.	Knox Megagroup	Prairie du Chien Group	Shokopee Dol.		
		New Richmond Beds		New Richmond Ss.	New Richmond Ss.			New Richmond Ss.		
		Lower Mogneson Proper		Oneota Dol.	Oneota Dol.			Gunter Fm.	Oneota Dol.	Blodgett Mbr.
					Arsenal Mbr.					
								Gunter Ss.		

Fig. O-6—Development of the classification of the Canadian Series.

except the northernmost part of the state (fig. O-9). Where overlain by New Richmond or Shakopee, the Oneota ranges in thickness from about 100 feet in the north to slightly over 300 feet in central Illinois. It is 200-500 feet thick to the southwest and probably considerably thicker to the southeast, where its boundaries are not distinct in the subsurface. The Oneota consists of fine- to coarse-grained, light gray to brownish gray, cherty dolomite that contains minor amounts of sand and, at its base, thin shaly beds. The chert is generally white, light or pinkish gray, or banded, and is in part sandy and oolitic. The chert occurs in layers, lenses, isolated nodules, and irregularly shaped bodies that have a distinctive branching habit. The coarse grain size characterizes the Oneota. In northern Illinois the formation is subdivided into the Arsenal Member, a very cherty lower unit, and the Blodgett Member, a slightly cherty and slightly sandy upper unit (Buschbach, 1964). The Oneota overlies the Gunter Sandstone, or, where the sandstone is absent, rests unconformably on the Cambrian Eminence Dolomite. The contact between the Oneota and the overlying New Richmond is sharp. Macrofossils are rare in the Oneota and are mostly gastropods and algal masses (fig. O-2E). The Oneota is equivalent to the Gasconade Formation of Missouri and to the upper nonsandy part of the Chepultepec Formation in the Kentucky subsurface.

**Arsenal Member**—The Arsenal Member of the Oneota Dolomite (Buschbach, 1964, p. 45) is the lower, very cherty member. It is named for the Joliet Arsenal, Will County, where the type section is represented in a boring (NE NE SW 25, 34N-9E) by samples (SS 6199) from 980-1085 feet deep. The Arsenal Member is recognized in the northeastern quarter of the state, where it varies from 90 to almost 200 feet thick. It is a cherty to very cherty dolomite that is light gray with some brown or pink tinting. The dolomite is medium grained but has some coarsely crystalline zones. The chert is white or light gray, partly banded, and only rarely oolitic. Sand grains are rare, but thin shale partings are common near the base.

**Blodgett Member**—The Blodgett Member of the Oneota Dolomite (Buschbach, 1964, p. 45) is the upper, noncherty, or only slightly cherty, member. It is named for the town of

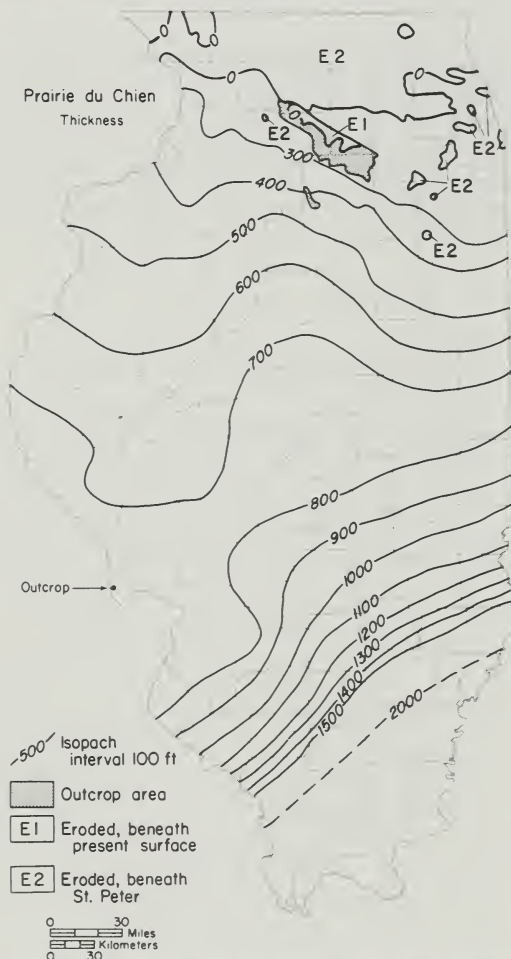


Fig. O-7—Thickness of the Prairie du Chien Group.

FORMATION	MEMBER		FEET
Shakopee Dol.			0-2000
New Richmond Ss.			0-150
Oneota Dol. (200-500)	Blodgett		90-100
	Arsenal		90-200
Gunter Ss.			0-25

Fig. O-8—Columnar section of the Prairie du Chien Group.

Blodgett, western Will County, 3 miles southwest of the type section, which is in a boring (NE NE SW 25, 34N-9E) and is represented by samples (SS 6199) from 885-980 feet deep. The Blodgett is recognized in the northeastern quarter of the state, where it ranges from 90 to over 100 feet thick. It is dolomite, sandy in part, very slightly glauconitic, light or pinkish gray, and medium to fine grained. Oolitic chert is present but not abundant. Thin green shale partings are widely spaced throughout the member.

*New Richmond Sandstone*

The New Richmond Sandstone (Wooster, 1882, p. 106), named for New Richmond, St. Croix County, Wisconsin, overlies the Oneota Dolomite and is overlain by the Shakopee Dolomite. It is well exposed along Franklin Creek, Lee County, and along the Fox River, west of Sheridan, La Salle County (Willman and Templeton, 1951). The New Richmond is present in the north-central and west-central parts of the state (fig. O-10). It is more than 100 feet thick in an area extending south-southwest from La Salle County to Jersey County, and it exceeds 150 feet in southern La Salle County. It is eroded from northernmost Illinois, and it wedges out southward and eastward. The New Richmond is sandstone with some interbedded sandy dolomite. The sandstone is white to light gray, fine to medium grained, subrounded to rounded, friable, moderately sorted, cross bedded, and ripple marked. The dolomite is sandy, light colored, fine grained, and contains oolitic chert. The characteristics of the dolomite are similar to those of the overlying Shakopee Dolomite. The heavy mineral suite in the New Richmond is characterized by abundant tourmaline and the presence of garnet (Willman and Payne, 1943). The contact at the base of the New Richmond is locally unconformable. The upper contact is transitional, and the New Richmond appears to grade upward and laterally into the Shakopee. The New Richmond Sandstone is equivalent to the lower part of the Roubidoux Formation in Missouri.

*Shakopee Dolomite*

The Shakopee Dolomite (Winchell, 1874, p. 138-139), named for outcrops at Shakopee, Scott County, Minnesota, overlies the New Richmond Sandstone or, where the New Richmond is absent, the Oneota Dolomite. It underlies the St. Peter Sandstone or, in southern Illinois, the Everton Dolomite. The Shakopee is exposed in Illinois along the Illinois River and its tributaries, from La Salle east to Utica, La Salle County; along the Fox River near Sheridan and Millington in La Salle and Kendall Counties; and along the Rock River and its tributaries between Franklin Grove, Lee County, and a point 2.5 miles west of Oregon, Ogle County (Willman and Templeton, 1951). It also occurs along the Mississippi River bluffs in Calhoun County in a small exposure on the crest of the Lincoln Anticline. In that locality it has been correlated with the Cotter (?) Dolomite (Rubey, 1952), but the Everton Dolomite has recently been traced to the adjacent area in Missouri, making it possible that the small Illinois outcrop may belong to the Everton. The Shakopee is present throughout much of Illinois (fig. O-11), but in the north-

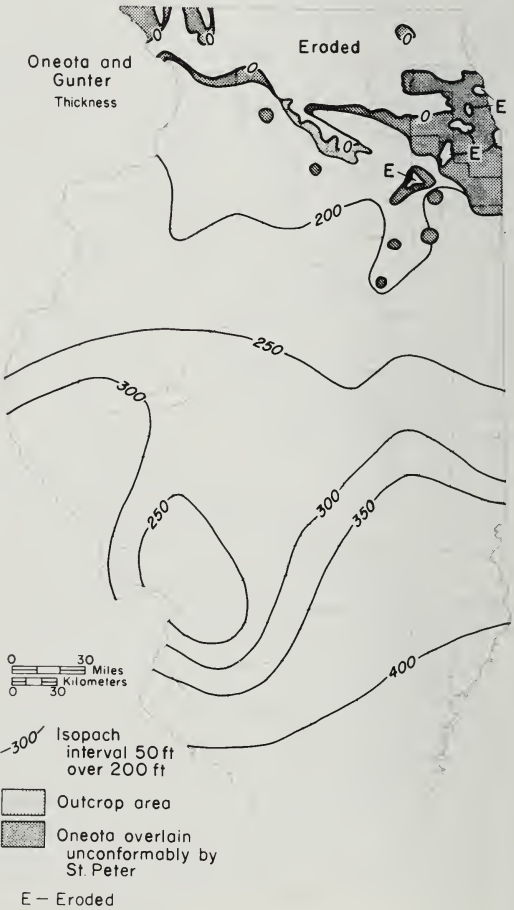


Fig. O-9—Thickness of the Oneota Dolomite and the Gunter Sandstone.

ern two tiers of counties it has been extensively removed by pre-St. Peter solution and erosion, and in north-central Illinois it is eroded from parts of the Ashton Arch and the Oregon Anticline near the Sandwich Fault Zone. Closely spaced wells in the northern half of the state show irregularities of 50-100 feet in the thickness of the Shakopee. It thickens regularly southward and reaches almost 600 feet at a line drawn between Edgar and Monroe Counties. South of that line the Shakopee is not separated from the underlying carbonates with confidence, but it appears that the Shakopee, chiefly by the addition of younger beds at its top, reaches a thickness exceeding 2000 feet near the southern tip of Illinois. The Shakopee consists of argillaceous to pure, very fine-grained dolomite with some thin beds of medium-grained, cross-bedded sandstone, medium-grained dolomite, green to light gray shale, and buff siltstone. The dolomite is light gray to light brown, with the brown increasing toward the deep part of the Illinois Basin. It contains oolitic, partly sandy chert in discontinuous bands and isolated nodules. Some beds of the Shakopee are brecciated or conglomeratic. Bedding surfaces show ripple marks and mud cracks. Several layers of bentonite are present in a quarry 2.5 miles west of Oregon (Willman and Templeton, 1951). Fossils are not abun-

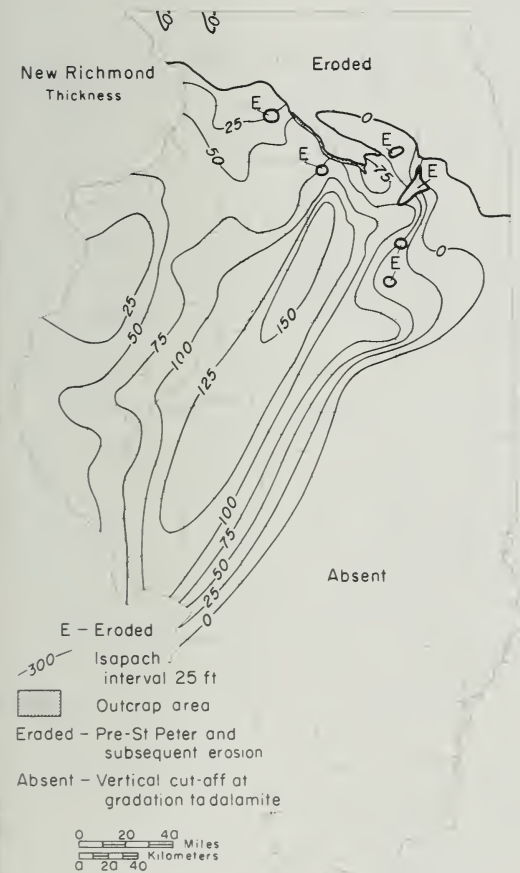


Fig. O-10—Thickness of the New Richmond Sandstone.

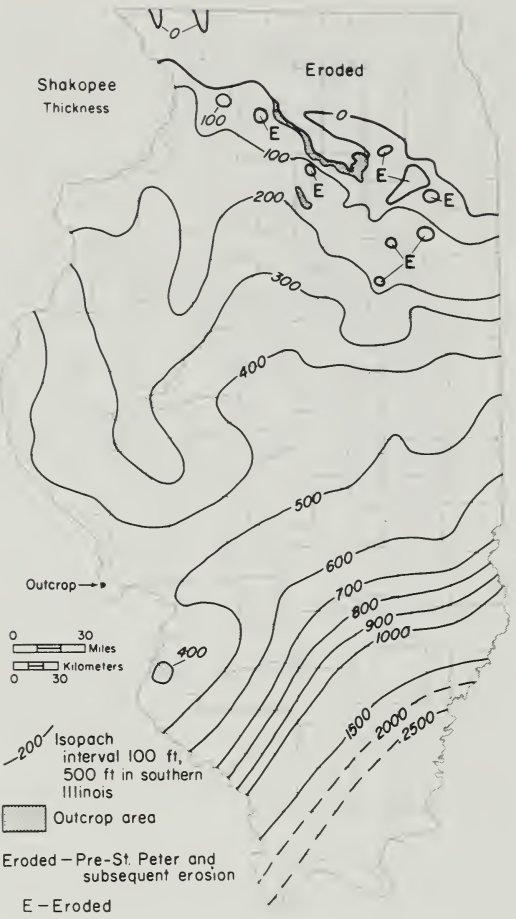


Fig. O-11—Thickness of the Shakopee Dolomite.

dant; those reported are chiefly gastropods and cephalopods. However, algal stromatolites are common in mats and domes that range from a few inches to more than 10 feet thick. The Shakopee is equivalent to the Jefferson City and Cotter Dolomites of Missouri, and to the south it may include strata equivalent to the younger Powell and Smithville—Black Rock Formations.

### TIPPECANOE SEQUENCE

The Tippecanoe Sequence (Sloss et al., 1949, p. 115), named for Tippecanoe County, Indiana, consists of the strata overlying the Sauk Sequence and underlying the Kaskaskia Sequence (fig. 14). In Illinois the base of the sequence is at the sub-St. Peter—Everton (sub-Champlainian) unconformity (fig. O-13), and the top is bounded by the sub-Dutch Creek—Wapsipinicon (sub-Middle Devonian) unconformity (fig. D-7). It, therefore, includes strata of middle to late Ordovician, Silurian, and early Devonian age. Although

minor or local unconformities occur within the sequence, its formations have a similar tectonic environment and are generally parallel throughout the state. They overlap the more deformed Sauk Sequence, and, in turn, were deformed and partly truncated before they were overlapped by the Kaskaskia Sequence.

CHAMPLAINIAN SERIES

The Champlainian Series (Emmons, 1842, p. 99-126; Schuchert and Barrell, 1914, p.

16, 25), named for Lake Champlain, New York, unconformably overlies Canadian dolomite throughout Illinois and is unconformably overlain by Cincinnati shales and limestone. The name "Champlainian" has been used in Illinois since 1963 (Templeton and Willman). Before then, these strata were called Middle Ordovician or subdivided into the Chazy and Mohawkian Series.

The Champlainian rocks are dominantly carbonates, mostly limestone in the south and dolomite in the north, but they include the St.

NORTHERN ILLINOIS																								
Worthen 1866		Bain 1905		Ulrich 1911		Cox 1914		Koy 1935		Agnew et al. 1956		Present, Templeton and Willman 1963												
F.	M.	F.	M.	F.	M.	F.	M.	G.	F.	F.	M.	Mg.	G.	Sg.	F.	St.								
Galena		Galena		Dubuque	Galena			Dubuque	Galena	Dubuque	Galena	Ottawa	Galena	Kimmswick	Dubuque	TRENTONIAN								
				Stewartville				Stewartville		Stewartville					Wise Lake									
				Prosser				Prosser		Prosser					Dunleith									
				Decorah				Decorah		Decorah					Guttenberg									
Trenton	Blue	Platteville	Blue	Platteville	Platteville			M.	Platteville	Spechts Ferry	Platteville		Plattin	Plattin	Spechts Ferry	BLACKRIVERAN								
								Decorah		Claybed					Decorah		Quimby's Mill							
										Glassrock					McGregor		Nachusa							
								Lower Buff									McGregor	Grand Detour						
St. Peters		St. Peter				Platteville		L. Buff		Pecatonica	Platteville		Ancell		Pecatonica									
								Glenwood		Glenwood					Glenwood									
SOUTHERN ILLINOIS													Present, Templeton and Willman 1963											
Worthen 1866		Ulrich 1904		Ulrich 1911		Weller 1940		DuBois 1945																
F.		F.		F.		F.		F.																
Trenton				McCune				Galena (Kimmswick)				Ottawa	Galena	Kimmswick	Wise Lake	TRENTONIAN								
				Upper Prosser											Dunleith									
				Kimmswick				Kimmswick							Guttenberg									
				Decorah				"Decorah"		"Decorah"					Kings Lake									
								Plattin		Plattin					Spechts Ferry									
				Plattin											Quimby's Mill									
				"Stones River"				Plattin (Platteville)		Nachusa														
				Joachim		Joachim		Joachim		Joachim					Grand Detour									
St. Peters		Pacific		St. Peter				Dutchtown		Dutchtown			Ancell		Joachim	BLACKRIVERAN								
								St. Peter		St. Peter					Dutchtown									
		Jefferson City				Everton						Knox			Everton	CH.								

F.=Formation, M.=Member, G.=Group, Mg.=Megagroup, Sg.=Subgroup, St.=Stoge, CH.=CHAZYAN

Fig. O-12—Development of the classification of the Champlainian Series.

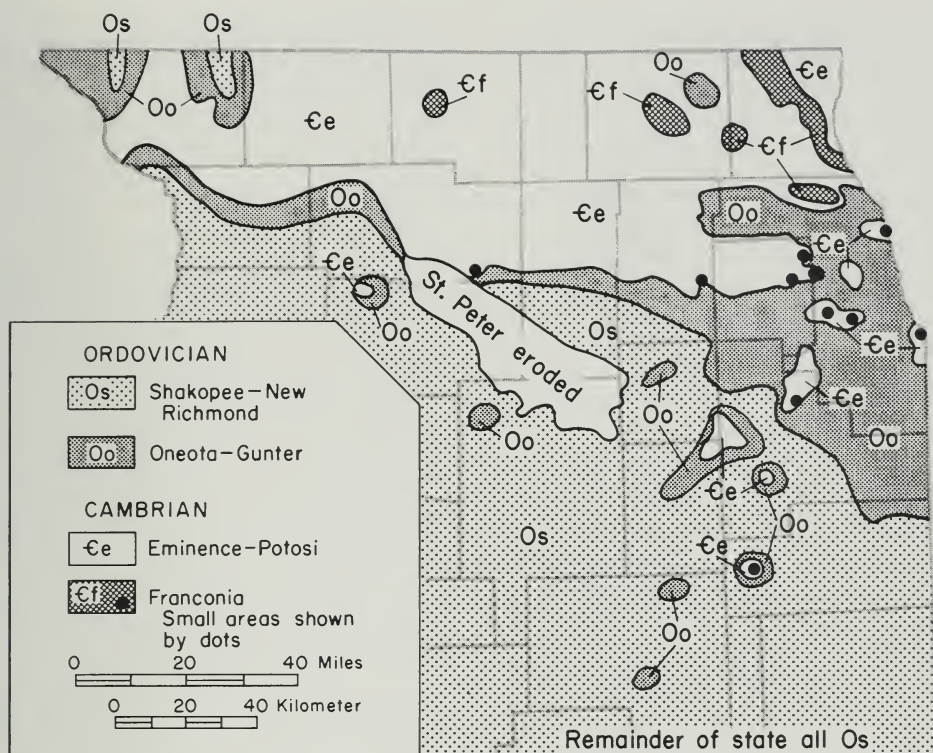


Fig. O-13—Geologic map of the sub-St. Peter surface in northern Illinois.

Peter Sandstone at the base, except in the southwestern part of the state where dolomite and sandstone of the Chazyan Everton Formation underlies the St. Peter. The series ranges in thickness from 1700 feet in the south to 500 feet in the north.

The Champlainian Series is subdivided into the Chazyan, Blackriveran, and Trentonian Stages (fig. O-4), which are based on the New York section (Kay, 1960). Although the classification in New York has been repeatedly modified, these stages have wide regional extent and their boundaries correspond to the major faunal and physical changes in the Champlainian of Illinois (Templeton and Willman, 1963). Different classifications developed in the outcrop areas in northern and southern Illinois, but many of the differences have been eliminated (fig. O-12).

The unconformity at the base of the Champlainian rocks is one of the major unconformities in Illinois. It separates the Sauk Sequence (below) from the Tippecanoe Sequence (above) (fig. 14). Throughout most of Illinois the sub-Tippecanoe unconformity cuts deeply into Canadian rocks and locally through both the Canadian and the Cambrian

Trempealeuan into Franconian rocks (fig. O-13). The Sauk Sequence dips southward in the Illinois Basin at a low angle, slightly greater than that of the overlying Tippecanoe Sequence (fig. 13). In the northern Illinois outcrop area, the Sauk rocks show more local deformation than the overlying Tippecanoe strata. Throughout most of Illinois the sub-Tippecanoe unconformity represents the combined effects of unconformities that occur both above and below the Chazyan strata, and the relative significance of the two unconformities has not been evaluated. The St. Peter Sandstone, which overlies the sub-Tippecanoe unconformity in most of the state, rests on a very irregular erosional surface, in part the result of a karst topography developed on the underlying carbonate rocks. A thick accumulation of residual materials (Kress Member) occurs at the base of the St. Peter in some localities (Buschbach, 1964).

An unconformity at the base of the Trentonian rocks is widespread and is accompanied by major changes in lithology and fauna, but it does not deeply truncate the underlying strata. The uppermost Blackriveran Quimbys Mill Formation is missing in some areas north

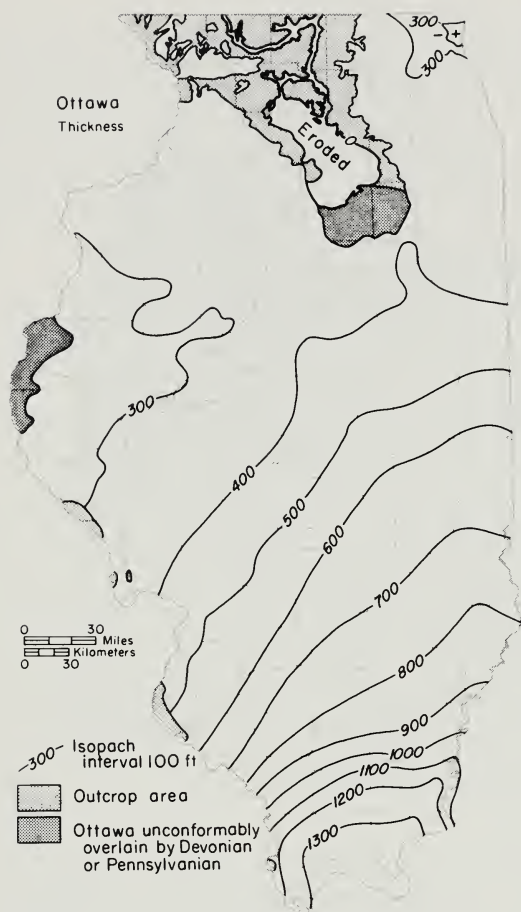


Fig. O-14—Thickness of the Ottawa Limestone Megagroup.

of Illinois, but in Illinois only the upper part is eroded, and that only locally. The Blackriveran-Trentonian contact generally is a strongly pitted, iron-stained corrosion surface. The basal Trentonian Spechts Ferry Formation thins eastward and is absent in the eastern half of Illinois, where it probably never was deposited.

Minor unconformities also occur in Champlainian strata at the base of the Pecatonica Formation and the base of the Guttenberg Formation, both accompanied by concentrations of phosphate nodules and the local absence of several feet of the underlying formation.

### Chazyan Stage

The Chazyan Stage (Emmons, 1842, p. 107; Grabau, 1909, p. 223), named for Chazy, New York, includes in Illinois only the Everton Dolomite, which is not exposed but

is encountered in drilling in the southwestern part of the state. The Everton is correlated with the type Chazyan on the basis of the fauna in the Everton type area in Arkansas and by subsurface tracing (Templeton and Willman, 1963).

### Everton Dolomite

The Everton Dolomite (Ulrich, 1907, p. 251-252), named for Everton, Arkansas, occurs in subsurface in southwestern Illinois. It is exposed only a few miles west of Illinois near Rockview and Dutchtown, south and west, respectively, of Cape Girardeau, Missouri. A major unconformity separates the Everton from Canadian rocks below, and a strong unconformity separates it from the St. Peter Sandstone above. The Everton Dolomite has been penetrated in only a few wells in Illinois, but at least locally it consists of a sandstone overlain by a dolomite. As these units were formerly considered unnamed formations, the Everton was classified as a group (Templeton and Willman, 1963), but more recently differentiation of the Everton in Illinois has seemed less feasible and the Everton is here classified as a formation. Although over 500 feet thick in southeastern Missouri and probably also in extreme southern Illinois, the Everton strata thin rapidly northeastward. They are 100-125 feet thick in Monroe County, Illinois, and are probably not present in Illinois north of St. Clair County, although a small exposure in Calhoun County, assigned to the Shakopee, may be Everton.

### Blackriveran Stage

The Blackriveran Stage (Vanuxem, 1842, p. 38-45; Moore, 1949), named for the Black River in New York State, consists of the strata included in the Ancell and Platteville Groups, which are present throughout most of Illinois (fig. O-19). Although the Ancell strata contain few fossils, the Platteville strata contain many that are characteristic of Blackriveran strata in New York (fig. O-5). Many of the distinctive lithologic units of the Platteville in Illinois have been traced to the Black River region in New York (Templeton and Willman, 1963).

### OTTAWA LIMESTONE MEGAGROUP

The Ottawa Limestone Megagroup (Wilson, 1938, 1946, p. 21; Swann and Willman, 1961, p. 478), named for Ottawa, Ontario, Canada, consists of the dominantly carbonate rocks overlying the St. Peter Sandstone and underlying the clastic rocks of the Cincinnati Series. It consists largely of the Galena and Platteville Groups, but in southwestern Illinois it includes at the top the Cape Limestone, which underlies the Maquoketa Shale Group, and at the base it includes the domi-

NORTHERN ILLINOIS				SOUTHERN ILLINOIS					
Group	Fm.	Member	Feet			Feet	Member	Fm.	
ANCELL	Glenwood	Harmony Hill	0-27			0-20	Metz	Joachim	
		Loughridge	0-22			0-40	Matson		
		Daysville	0-75			0-60	Defiance		
		Kingdom	0-40			0-30	Boles		
	St. Peter	Starved Rock		0-235			0-106	Augusta	Joachim
						0-150	Abernathy		
		Tonti	30-300			0-100	Sharpsboro	Dutchtown	
						0-130	Gordonville		
		Kress	0-170			0-30	Starved Rock	St. Peter	
				65-150		Tonti			
					0-10	Kress			

Fig. O-15—Columnar section of the Ancell Group (after Templeton and Willman, 1963).

nantly dolomite Dutchtown and Joachim Formations in the upper part of the Ancell Group. At the base in northern Illinois it locally includes the Daysville Dolomite Member of the Glenwood Formation. The Ottawa Megagroup underlies most of the state and thickens from about 300 feet in northern Illinois to 1300 feet in southern Illinois (fig. O-14). In local areas where the St. Peter Sandstone is absent, the Ottawa Megagroup rests on the Knox Dolomite Megagroup but generally is readily distinguished from it.

### Ancell Group

The Ancell Group (Templeton and Willman, 1963, p. 29), named for Ancell in southeastern Missouri, consists of the sandstone and the argillaceous and sandy limestone and dolomite formations that overlie the Everton Dolomite and underlie the Platteville Group, which is relatively pure limestone. The type section is a composite of several sections in the bluffs north of Ancell, between

Dutchtown and Rock Levee, Missouri. As the Everton is present only in southern Illinois, the Ancell Group overlies Canadian strata in most of the state or Cambrian strata locally. Ancell strata underlie most of Illinois, and they vary in thickness from a few feet to as much as 900 feet. The St. Peter Sandstone is the basal formation in the group. North of a line roughly extending from Chicago to Quincy, the Ancell strata above the St. Peter Sandstone consist of the members of the Glenwood Formation, but south of that line they consist of the Joachim and Dutchtown Formations (fig. O-15). The Glenwood, Dutchtown, and Joachim Formations all appear to have a facies relation to the upper part (Starved Rock Member) of the St. Peter Sandstone (fig. O-16).

### St. Peter Sandstone

The St. Peter Sandstone (Owen, 1847, p. 169-170; Calvin, 1906, p. 73; Bevan, 1926, p. 6) is named for the St. Peter River in Minnesota, now called the Minnesota

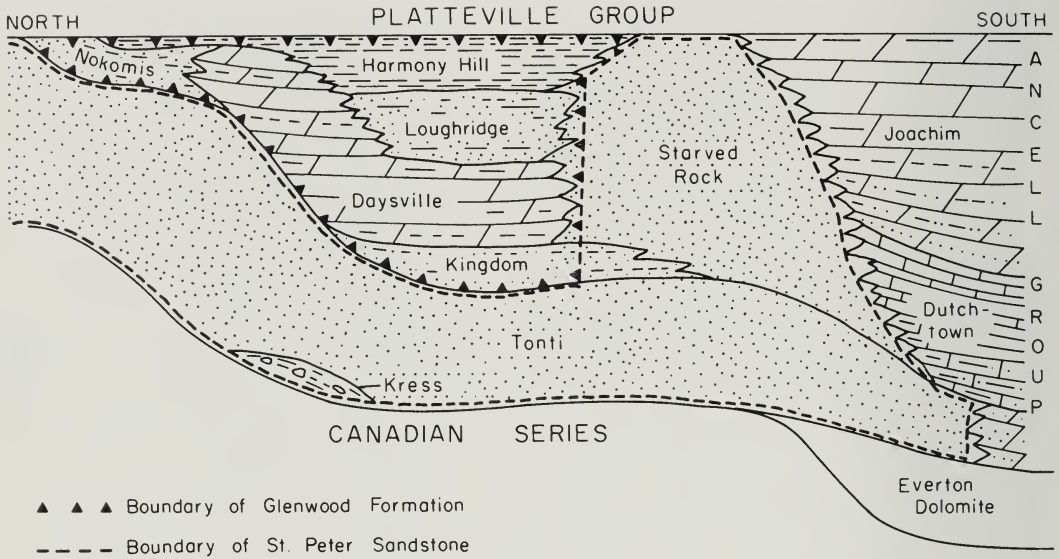


Fig. O-16—Diagrammatic cross section of the Ancell Group (after Templeton and Willman, 1963).

River. The type section is in the river bluffs at Fort Snelling on the southeast edge of Minneapolis. The St. Peter Sandstone is present in most of Illinois (fig. O-17). Because of a major unconformity at its base, the St. Peter truncates formations as old as the Cambrian Franconia Formation (fig. O-13). It is generally overlain by the Glenwood Formation in northern Illinois, the Joachim Dolomite in the central part of the state, and the Dutch-town Limestone in the extreme south, and it has a facies relation to these formations (fig. O-16). The St. Peter is well exposed along the Illinois and Fox Rivers near Ottawa (fig. O-2A), the Rock River near Oregon, and the Mississippi River near West Point Landing in Calhoun County. The St. Peter Sandstone varies from only a few feet to more than 700 feet thick, but commonly it is 100-200 feet thick. The greater thicknesses occur in northern Illinois, where the pre-St. Peter surface had sharp relief on a strongly developed karst topography and a north-facing escarpment of early Ordovician and late Cambrian dolomite formations (Buschbach, 1961). The St. Peter consists largely of fine to medium, well sorted, well rounded, frosted grains of quartz sand that is friable or weakly cemented. Except in a few local areas, the St. Peter is exceptionally pure quartz sand, essentially free from clay, carbonates, and heavy minerals. Some beds have low-angle cross bedding, but the bedding is largely horizontal (Lamar, 1928a; Willman and Payne, 1942; Buschbach, 1964). The St. Peter includes three members, the Kress Member at the base (chert, sand, clay, and shale), the Tonti Sandstone Member, and the Starved Rock Sandstone Member (fig. O-15). The St. Peter is nonfossiliferous, except for local worm borings (*Scolithus*) and a few scolecodonts in the upper part of the formation. The St. Peter is generally considered to be a marine sand deposited near the shore of a sea advancing from the south (Dapples, 1955). It is equivalent to a sandy zone at the base of the Pamela Formation in New York and to a light-colored dolomite at the base of the Murfreesboro Limestone in Tennessee. The St. Peter

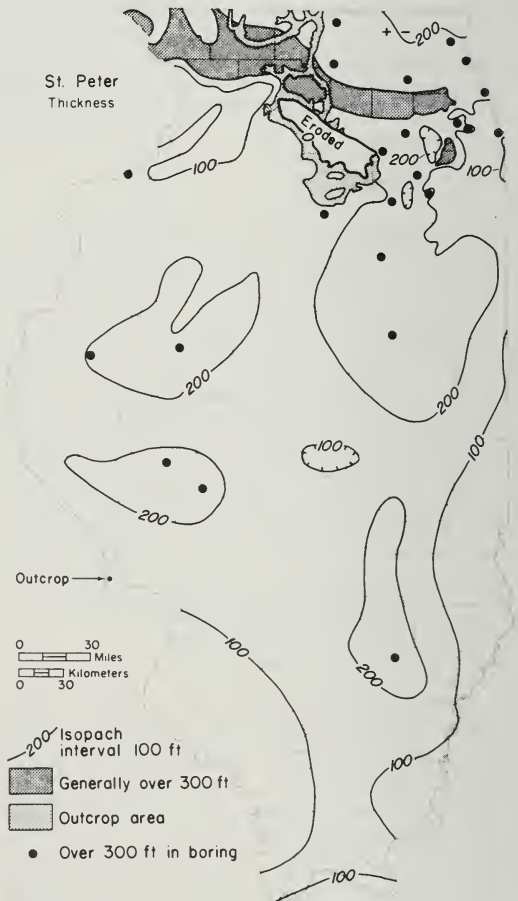


Fig. O-17—Thickness of the St. Peter Sandstone.

Sandstone is extensively quarried for silica sand and is one of the major aquifers in Illinois.

**Kress Member**—The Kress Member of the St. Peter Sandstone (Buschbach, 1964, p. 51), the basal member, is named for Kress Creek, a stream northwest of West Chicago, Du Page County, near which a well (NW NE SE 32, 40N-9E) encountered 64 feet of conglomerate at the base of the St. Peter, the top at a depth of 940 feet. The type section is represented by samples from the well (SS 1169). The Kress Member is very irregular in occurrence but has been encountered in many wells. Its maximum thickness is 170 feet in a well in Ogle County, where a thin layer of bentonite occurs near its base. The Kress in some places is a coarse rubble or conglomerate of chert in a matrix of clay or sand, a residue from the solution of the underlying cherty dolomites and sandstones. At other places the Kress is largely red sandy clay, red and green shale, and argillaceous sandstone that represent reworking of the residual materials by the advancing St. Peter sea. The conglomerate is locally exposed in the Oregon region, Ogle County, and the shale is exposed at Utica, La Salle County.

**Tonti Sandstone Member**—The Tonti Sandstone Member of the St. Peter Sandstone (Templeton and Willman, 1963, p. 45), the middle member, is named for Tonti Canyon in

Starved Rock State Park. The top of the sandstone is exposed in the canyon, but the type section is at Starved Rock, La Salle County (SW NW 22, 33N-2E), where the contact with the overlying Starved Rock Sandstone Member and the upper 40 feet of the Tonti Member are exposed. The Tonti is entirely exposed in the bluffs at Split Rock, 4 miles northwest of Starved Rock. The Tonti Member generally forms the greater part of the St. Peter Sandstone, and in many areas all the St. Peter is Tonti. Although commonly from 100-200 feet thick, it is locally over 500 feet thick. The Tonti Member is chiefly fine-grained, well sorted, friable, highly porous sandstone, but locally in western Illinois it is even finer grained, silty, less porous, and partly cemented by secondary silica. It is noncalcareous, except in southern Illinois where it contains some dolomitic beds.

**Starved Rock Sandstone Member**—The Starved Rock Sandstone Member of the St. Peter Sandstone (Templeton and Willman, 1963, p. 46), the uppermost member, is named for Starved Rock in Starved Rock State Park, La Salle County. The type section is in Starved Rock and French Canyon (W1/2 NW 22, 33N-2E), where the member is 90 feet thick. All except the upper few feet of the member is exposed in Starved Rock. The Starved Rock Sandstone differs from the Tonti Member in being largely medium grained rather than fine grained and somewhat more cross bedded. It has a sharp contact with the Tonti Sandstone in most exposures (Willman and Payne, 1942). It is commonly 60-100 feet thick and occurs in a broad band, extending southwestward from the Chicago area to the Mississippi River in the Quincy area (fig. O-18). It is locally present in extreme southern Illinois. The Starved Rock Member is believed to represent an offshore bar that separated Glenwood sedimentation on the north from Joachim sedimentation on the south, and it has a facies relation to both. At Starved Rock the lower part of the member contains thin beds with the poor sorting characteristic of the sandstones in the Glenwood Formation.

## Glenwood Formation

The Glenwood Formation (Calvin, 1906, p. 60-61; Bevan, 1926, p. 6), a highly varied unit of sandstone, dolomite, and shale overlying the St. Peter Sandstone, is named for Glenwood Township, Winneshiek County, northeastern Iowa. The type section is in a ravine 3 miles northeast of Decorah (SE SW 6, 98N-7W). The Glenwood Formation is widely present in northern Illinois (fig. O-18). It underlies the Platteville Group, from which it is separated by an unconformity that is widespread and sharp but has only minor relief. It is exposed in Illinois only in the Rock River region above Dixon. Although absent in some localities, especially near the Wisconsin state line, thicknesses of 25-50 feet are common and the formation is as much as 75 feet thick in places. The Glenwood Formation is characteristically poorly sorted sandstone, impure dolomite, and green shale. The sandstones have a distinctive bimodal, or "pudding stone," texture, with medium grains of well rounded quartz sand, like those of the St. Peter Sandstone, in a matrix of very fine sand and coarse silt. This is frequently referred to as Glenwood texture, in contrast to the well sorted St. Peter texture. The Glenwood sandstones also contain a variety of heavy minerals, including abundant garnet, whereas the St. Peter has a very low content of a limited suite of heavy minerals, consisting largely of tourmaline and zircon. The Glenwood Formation is subdivided into five members—the Kingdom Sandstone Member at the base is overlain by the Daysville Dolomite Member, the Loughridge Sandstone Member, and the Harmony Hill Shale Member. The lower three have gradational contacts and

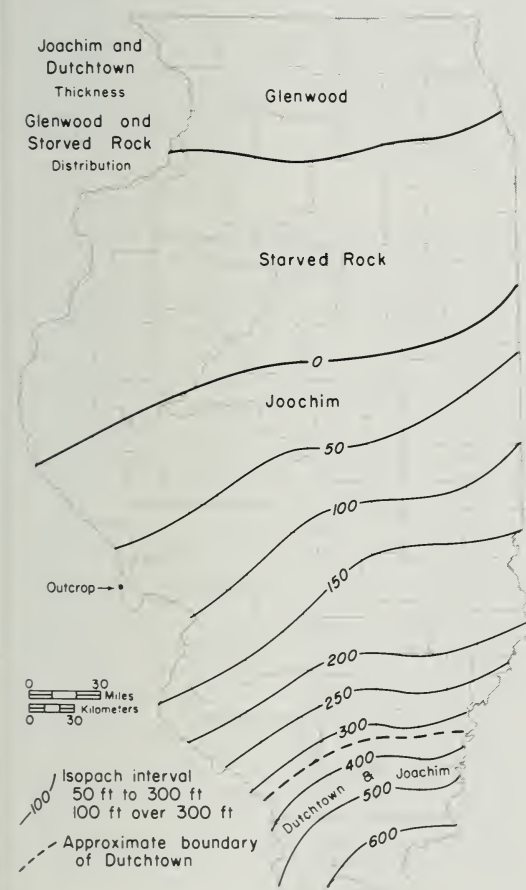


Fig. O-18—Thickness of the Dutchtown Limestone and Joachim Dolomite and the distribution of the Starved Rock Sandstone Member of the St. Peter Sandstone and the Glenwood Formation.

generally thicken and thin at the expense of each other. Locally in northwestern Illinois the Daysville Dolomite Member is absent, and the name "Nokomis Sandstone Member" is applied to all the sandstone of Glenwood type underlying the Harmony Hill Shale. In extreme western Illinois the St. Peter Sandstone is overlain by a green shale, above which a well sorted St. Peter-like sandstone is informally called the "Re-Peter" sandstone. In Illinois the green shale has been correlated with the Kingdom Sandstone and the "Re-Peter" with the Starved Rock Sandstone (Templeton and Willman, 1963). In Iowa the green shale has been correlated (Agnew, 1955) with type Glenwood Shale, which is the Harmony Hill Shale. If the latter is correct, the "Re-Peter" may correlate with the Hennepin Sandstone Member, which in places is a St. Peter-like sandstone at the base of the overlying Pecatonica Formation. The Glenwood Formation contains a few worm borings, a few scolecodonts, and, in places, dark red algae or spores.

**Kingdom Sandstone Member**—The Kingdom Sandstone Member of the Glenwood Formation (Templeton and Willman, 1963, p. 49), the basal member, is named for Kingdom, Lee County, which is 3 miles south of the type section (ravine in NE SE NW 36, 23N-9E, Ogle County), where it is 7.9 feet thick. It commonly is 5-20 feet thick but has a maximum thickness of 40 feet. It has the poor sorting typical of the Glenwood texture. In most of the outcrops it has a sharp contact with the underlying Tonti Sandstone Member of the St. Peter. It thins northward and westward as it grades into the overlying Daysville Member, and farther north it is equivalent to the lower part of the Nokomis Member.

**Daysville Dolomite Member**—The Daysville Dolomite Member of the Glenwood Formation (Templeton and Willman, 1963, p. 50), which commonly overlies the Kingdom Sandstone Member, is named for Daysville, Ogle County, which is 3 miles southwest of the type section (ravine in NW NW SW 6, 23N-11E), where it is 23.8 feet thick. It is commonly 15-25 feet thick in the outcrop area but is about 45 feet thick, and locally 75 feet thick, in subsurface in an area extending from De Kalb County eastward to Lake Michigan. It thins rapidly northward, and southward it grades into the Starved Rock Member of the St. Peter Sandstone. The Daysville is the only calcareous member of the Glenwood. It is largely argillaceous, silty, sandy, greenish gray to white, chalky to dense dolomite and occurs in irregular beds. Locally it is conglomeratic with intraformational dolomite pebbles, and, where it directly overlies the Tonti Sandstone Member of the St. Peter, the basal part contains interbedded layers of sandstone of the St. Peter type. Worm borings are the only fossils known.

**Loughridge Sandstone Member**—The Loughridge Sandstone Member of the Glenwood Formation (Templeton and Willman, 1963, p. 51), the upper sandstone member, is named for Loughridge School, which is 5 miles northwest of the type section, a ravine 4 miles north of Grand Detour, Ogle County (N $1\frac{1}{2}$  NW NE NE 25, 23N-9E), where it is 9.8 feet thick. It is differentiated only in the area where the Daysville Dolomite is present. The Loughridge is commonly less than 10 feet thick in the outcrop area but is 22 feet thick in a well at Dixon. It has the typical Glenwood texture. It merges westward and northward with the upper part of the Nokomis Sandstone Member and southward in subsurface with the Starved Rock Sandstone Member of the St. Peter Sandstone.

**Nokomis Sandstone Member**—The Nokomis Sandstone Member of the Glenwood Formation (Templeton and Willman, 1963, p. 51), which commonly includes all the sandstone of the formation in extreme northern Illinois and farther north, is named for Lake Nokomis, 1.5 miles west of the

type section in the bluff on the west side of the Mississippi River at Lock and Dam No. 1 in Minneapolis, Minnesota, where the member is 10.8 feet thick. It rests on the St. Peter Sandstone and is overlain by the Harmony Hill Shale Member. The Nokomis Member results from the merger northward of the Kingdom and Loughridge Sandstone Members beyond the margin of the intervening Daysville Dolomite Member. It has the typical Glenwood texture and generally rests sharply on the underlying St. Peter Sandstone. It has a maximum thickness of 11 feet in Illinois but is generally less than 5 feet and is absent in places.

**Harmony Hill Shale Member**—The Harmony Hill Shale Member of the Glenwood Formation (Templeton and Willman, 1963, p. 52), the uppermost member, is named for Harmony Hill School, which is 1 mile northwest of the type section, a ravine 5 miles north of Grand Detour, Ogle County (W $1\frac{1}{2}$  SE SE NE 24, 23N-9E), where the member is 5.9 feet thick. It is the most widely distributed member of the Glenwood Formation but is locally absent in the outcrop area and is generally absent in subsurface in northeastern Illinois. It is commonly 1-5 feet thick but has a maximum thickness of 27 feet in southwestern Ogle County. The Harmony Hill Member is a green, pyritic, finely laminated shale containing thin laminae of silt and very fine sand, but in places it becomes very sandy, and locally it is black. Phosphatic pellets are common near the top. It contains a few fragments of scolecodonts, *Lingula*, and minute, dark red algae or spores. It is conformable, usually gradational, with the underlying members, but it locally rests unconformably on the St. Peter Sandstone. It is unconformably overlain by the Pecatonica Formation. In some areas in the Upper Mississippi Valley it is the only unit included in the Glenwood and is called the Glenwood Shale.

## Dutchtown Limestone

The Dutchtown Limestone (McQueen, 1937, p. 12), which overlies the St. Peter Sandstone and underlies the Joachim Dolomite in extreme southern Illinois (fig. O-18), is named for Dutchtown, Cape Girardeau County, Missouri. The type section is in a bluff 1 mile east of Dutchtown. The Dutchtown Limestone is not exposed in Illinois, but it has been penetrated in wells as far north as southern Jackson County, thinning in that direction from a known thickness of about 150 feet in the Cape Girardeau area (fig. O-18). However, drilling near by in Kentucky suggests it is as much as 200 feet thick in southeastern Illinois (DuBois, 1945; Templeton and Willman, 1963). The Dutchtown is largely dark gray (nearly black), argillaceous, lithographic limestone and dolomite. When freshly broken it has a strongly fetid odor. It contains beds of gray and brown shaly limestone and dolomite, calcareous siltstone, and dolomitic sandstone. Its dark color and prevalence of limestone differentiates it from the overlying Joachim Dolomite. It is differentiated into two members, the Gordonville below (largely dolomite) and the Sharpsboro above (largely limestone). The Dutchtown is fossiliferous, and mollusks, ostracodes, and conodonts are the most abundant fossils. It appears to grade laterally into the St. Peter Sandstone. The Dutchtown Limestone is correlated with similar dark limestone in the Murfreesboro Limestone in Tennessee and the Pamela Limestone in New York.

**Gordonville Member**—The Gordonville Member of the Dutchtown Limestone (Templeton and Willman, 1963, p. 54), the lower member, is named for Gordonville, Cape Girardeau County, Missouri, 4.5 miles northwest of the type sec-

tion, which is in the Geiser Quarry, 1.25 miles east of Dutchtown (SW NW NW 20, projected, 30N-13E), where the upper 5 feet is exposed. In wells in Illinois the Gordonville Member ranges from 130 feet thick in southern Pulaski County to 45 feet in southwestern Jackson County, north of which it thins out rapidly. It does not extend as far north as the overlying Sharpsboro Member. The Gordonville Member normally consists of dolomite with subordinate amounts of limestone, but in southern Jackson County, close to the transition into the St. Peter Sandstone, it is composed mainly of dolomite-cemented, medium-grained sandstone. The dolomite and limestone are mostly sandy, silty, greenish gray to dark gray, and a few layers are dark brown to black.

**Sharpsboro Member**—The Sharpsboro Member of the Dutchtown Limestone (Templeton and Willman, 1963, p. 55), the upper member, is named for Sharpsboro, Cape Girardeau County, Missouri, a railroad station 5.5 miles southeast of the type section, the same as that for the Gordonville Member, where the lower 10.5 feet of the Sharpsboro is exposed. The Sharpsboro Member is 65 feet thick in a well in Pulaski County, but it is 100 feet in the type locality, as shown by a well at Cape Girardeau, Missouri. It apparently thins out rapidly in Jackson County, Illinois, extending only a short distance north of the limit of the Gordonville Member. The Sharpsboro Member is largely a dark gray, dark brown, or black lithographic limestone. It contains beds of dark gray dolomite, sandy limestone, and dark brown shale. A few beds of light gray dolomite, like that found in the Joachim above, occur near the top. The contact with the Joachim is conformable. The fauna of the Dutchtown Limestone comes largely from the Sharpsboro Member.

## Joachim Dolomite

The Joachim Dolomite (Winslow, 1894, p. 331, 352; McQueen, 1937, p. 12), the uppermost formation in the Ancell Group in southern Illinois, is named for Joachim Creek in Jefferson County, Missouri, along which the lower part is partially exposed. A more complete section in the bluffs between Cape Girardeau and Dutchtown, Missouri, has been suggested as a supplementary reference section (Templeton and Willman, 1963, p. 55). The Joachim Dolomite is exposed in Illinois only in Calhoun County (fig. O-2D), where the Mississippi River cuts through the Lincoln Anticline. However, it underlies all of Illinois south of a line extending from near Quincy to Kankakee (fig. O-18). North of there it has a gradational contact with the Starved Rock Member of the St. Peter Sandstone. The Joachim thins northward by progressive termination of the basal Joachim strata. It is as much as 385 feet thick in extreme southern Illinois. The Joachim Dolomite has a highly varied lithology, but individual units are widely persistent. Although largely light gray, argillaceous, silty or sandy dolomite, it contains beds of brownish gray, relatively pure dolomite, beds of sandstone and limestone, some thin shale beds, and numerous algal domes of pure dolomite. In the outcrop area, chert occurs only near the middle, but it is more common in the subsurface in Illinois. Layers of anhydrite in the subsurface appear to have been dissolved in the outcrop area, producing the brecciated layers that are common in the dolomite. Mud cracks and ripple marks are common in some beds. The general absence of marine fossils suggests that the Joachim was deposited in a shallow, closed basin. The Joachim contains much more clastic material than the Platteville strata above, which are dominantly limestone in the area where the Joachim is present. It is lighter colored than the Dutchtown below. The Joachim

Dolomite is best exposed on the flanks of the Ozark Dome in Missouri, and it is differentiated into six members on the basis of exposures in that area. The Abernathy Member (at the base) is sandy, the Augusta is thick bedded and silty, the Boles is thin bedded and shaly, the Defiance is thick bedded and silty, the Matson is brown, pure, and massive, and the Metz (at the top) is thin bedded and silty. Only the Metz, Matson, and the top of the Defiance are exposed in Illinois, but all the members can generally be recognized in samples from wells. All are successively overlapped northward. In Missouri the name "Joachim" is restricted to the units below the Boles, and the overlying beds are included in the Rock Levee Formation. The Joachim Dolomite is correlated with the upper part of the Pamela Formation in New York.

**Abernathy Member**—The Abernathy Member of the Joachim Dolomite (Templeton and Willman, 1963, p. 58), the basal member, is named for Abernathy School, 2 miles north of the type section, which is 1.5 miles east of Dutchtown, Missouri (SE NW NE 20, projected, 30N-13E). The upper 25.6 feet is exposed at the type section. In southern Illinois the Abernathy is present in the subsurface, extending northward as far as Jackson County. It is as much as 150 feet thick in a well in Pulaski County but more commonly is 50-100 feet thick. The Abernathy Member is largely silty, sandy, thick-bedded dolomite containing layers of dolomitic, medium-grained sandstone. It contains some dark brown layers of limestone and dolomite. A persistent layer of sandstone of St. Peter type 1.5-14 feet thick occurs at the top. Chert is common just below the sandstone.

**Augusta Member**—The Augusta Member of the Joachim Dolomite (Templeton and Willman, 1963, p. 59), which overlies the Abernathy Member, is named for Augusta, Franklin County, Missouri, 5 miles west of the type section, which is a railroad cut on the south side of the Missouri Valley a mile southwest of St. Albans (SW NE SW 10, 44N-2E), where the member is 29 feet thick. It extends northward in subsurface as far as southern Calhoun County, Illinois, where it is 16 feet thick. It thickens southward, is generally 50-75 feet thick in the outcrops in Missouri, and is 106 feet thick in a well in Pulaski County, Illinois. The Augusta Member consists of relatively pure to very silty, light gray, white-weathering dolomite, generally in thick beds. The member contains layers of pure, brown, algal dolomite or limestone. Many individual beds are distinctive and can be widely traced. Locally the basal part is a siltstone or contains layers of green shale, indicative of its facies relation to the upper part of the St. Peter Sandstone. The Augusta is less sandy and the sand is finer grained than that in the Abernathy Member below; it is thicker bedded and less shaly than the Boles above.

**Boles Member**—The Boles Member of the Joachim Dolomite (Templeton and Willman, 1963, p. 60), which overlies the Augusta Member, is named for Boles, Franklin County, Missouri, 6 miles southwest of the type section, a quarry on the north side of the Missouri Valley 1 mile southwest of Matson, St. Charles County (NE cor. SE NE SW 4, 44N-2E), where the member is 19.1 feet thick. The Boles Member is commonly about 20 feet thick, ranging from 15-30 feet. It consists largely of thin to medium beds of dense silty dolomite and vuggy pure dolomite, separated by layers of dark red-brown to gray-green shale as much as 5 inches thick. Many bedding surfaces are ripple marked, and mud cracks are common. It contains several bands of white to black chert nodules and is the only persistent chert zone in the outcropping Joachim. However, chert is absent in places, and in subsurface in Illinois it occurs in other members of the Joachim. The Boles is distinguished from both the Augusta below and the Defiance above by its thin bedding, abundance of shale, and the chert bands.

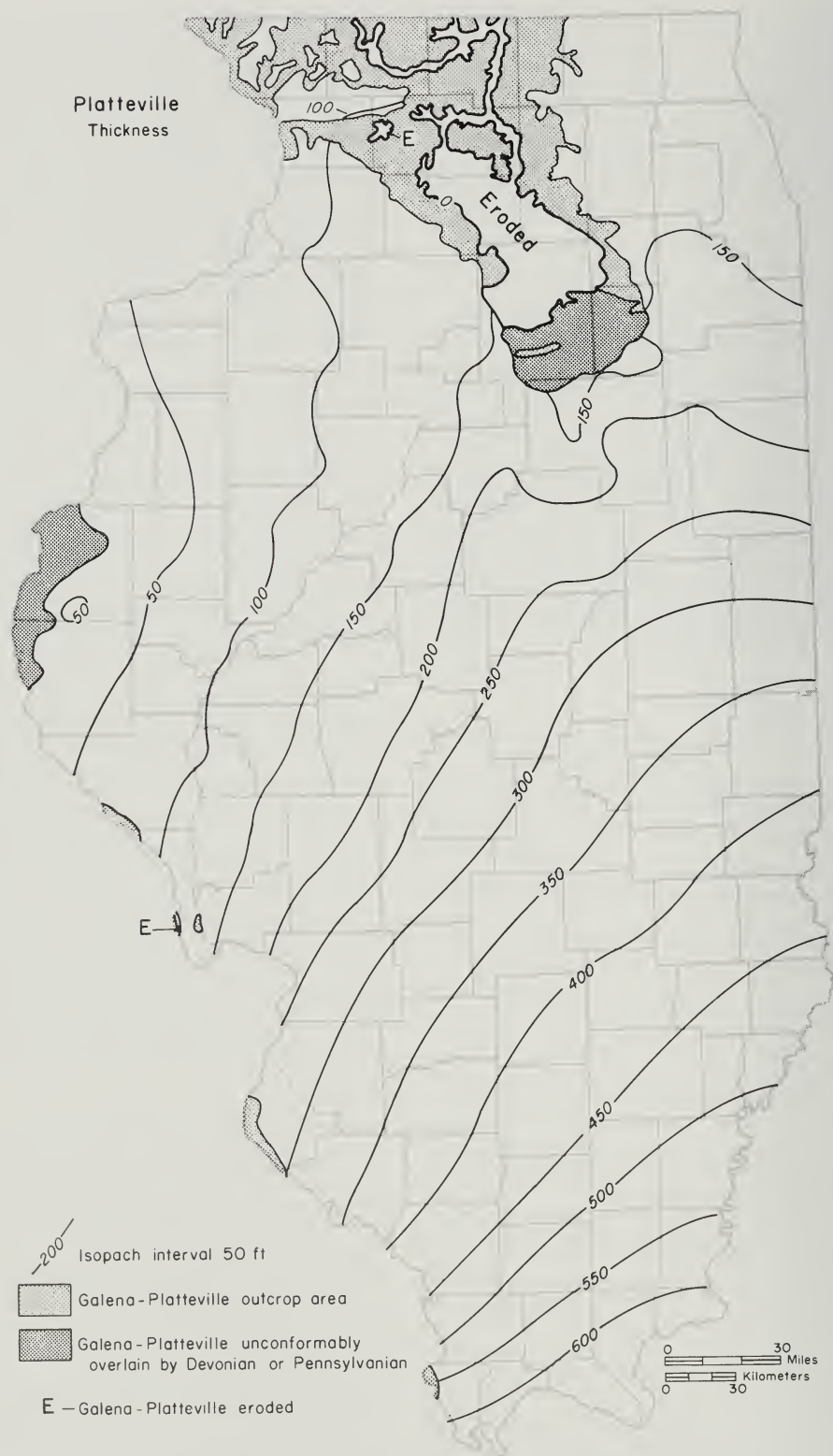


Fig. O-19—Thickness of the Platteville Group.

**Defiance Member**—The Defiance Member of the Joachim Dolomite (Templeton and Willman, 1963, p. 60), which overlies the Boles Member, is named for Defiance, St. Charles County, Missouri, 3 miles northeast of the type section, the same exposure as the Boles Member type section, where the Defiance is 20.5 feet thick. The Defiance Member is exposed in Illinois only in the Mississippi bluffs at West Point Landing, Calhoun County. The Defiance Member is usually 20-40 feet thick and dominantly silty dolomite. It contains numerous algal domes, and beds of limestone are common in the southern part of the outcrop area. The Defiance Member is similar in lithology to the Augusta Member.

**Matson Member**—The Matson Member of the Joachim Dolomite (Templeton and Willman, 1963, p. 61), which overlies the Defiance Member, is named for Matson, St. Charles County, Missouri, just east of the type section in the north bluff of the Missouri Valley (NE NE NE 4, projected, 44N-2E), where the member is 29.8 feet thick. The Matson Member persists throughout the area of the Joachim. In Illinois it is exposed only at West Point Landing in Calhoun County, where it is 21 feet thick. It is about 30 feet thick in the outcrop area, but in subsurface in Illinois it commonly is 15-40 feet thick. The Matson Member differs from the other Joachim Members in being relatively pure, brown, finely porous dolomite that generally appears to be massive but is finely laminated, the laminae separated by thin films of dark brown clay. Locally it contains a few thin beds of the lithologic types common in the Defiance and Augusta Members. The Matson appears to be largely algal in origin. Ostracodes occur locally in the basal beds, and a marine fauna with corals, brachiopods, and trilobites has been observed in the basal beds at one locality near Zell, Missouri.

**Metz Member**—The Metz Member of the Joachim Dolomite (Templeton and Willman, 1963, p. 62), which overlies the Matson Member, is named for Metz Lake, 5 miles north of the type section, a quarry in the east bluffs of the Mississippi River, just north of West Point Landing, Calhoun County (SE NE SE 19, 7N-2W), where the member is 9.5 feet thick. The Metz Member is present throughout the area of the Joachim Dolomite and commonly is about 15 feet thick, ranging from 7-20 feet. The Metz consists of light gray, silty, thin- to medium-bedded dolomite but has a few beds of pure, darker dolomite. It contains algal domes, mud-cracked surfaces, and scour surfaces. It differs from the underlying relatively pure Matson Member, but many of the beds have a lithology similar to that of the Defiance and Augusta Members. The dominance of dolomite differentiates it from the relatively pure, lithographic limestone of the Platteville Group, which overlies it unconformably.

## Platteville Group

The Platteville Group (Bain, 1905, p. 18-21; Calvin, 1906, p. 60-61; Templeton and Willman, 1963, p. 63) is named for Platteville, Wisconsin, which is 4 miles east of the type exposures along the Little Platte River. For a specific type section, Kay (1931, p. 369, 371) designated a ravine exposure (SW NW NW 20, 3N-1W, Grant County, Wis.), but Templeton and Willman (1963) suggested as an alternate a more accessible roadcut 5 miles southwest of Platteville (SE SW SE 1, 2N-2W), where the group is 53.6 feet thick. In the type region, the Platteville Group includes the dominantly limestone formations that overlie the Glenwood Formation

of the Ancell Group and underlie the Spechts Ferry or Guttenberg Formations of the Galena Group. In an east-west area through central Illinois it overlies the St. Peter Sandstone, and south of there it overlies the Joachim Dolomite. The Platteville Group is widely exposed in northern Illinois—in the Rock and Pecatonica Valleys above Dixon, in a small area near Galena in Jo Daviess County, and near Ottawa and La Salle in La Salle County (fig. O-19). The southern outcrop area, largely in Missouri on the east flank of the Ozark Dome, extends from Cape Girardeau north to St. Louis and, beyond a short covered interval, to exposures on the Lincoln Anticline. In Illinois the Platteville crops out at West Point Landing in Calhoun County (fig. O-2D). The group is only about 30 feet thick in extreme western Illinois, but it thickens to 135 feet in the Dixon outcrop area and southward to over 600 feet in subsurface in the extreme southern part of the state. In northern Illinois the Platteville Group is largely blue-gray, lithographic, partly dolomite-mottled limestone, but in some areas, such as that near Dixon, it is gray, very fine-grained, cherty dolomite. In southern Illinois it is largely brown, lithographic, partly dolomite-mottled, slightly shaly limestone. It is subdivided (fig. O-20) into the Platin Subgroup (above) which is dominated by the typical limestone facies, and the Pecatonica Formation, a persistent dolomite except where it grades to limestone in southern Illinois. The units are separated by a widespread corrosion surface, probably a diastem. The Platin Subgroup is subdivided into the Mifflin (at the base), Grand Detour, Nachusa, and Quimbys Mill Formations on the basis of differences in purity, bedding, and texture. The Platteville formations and members have great lateral continuity and many of them are recognized in samples from borings (Buschbach, 1964). The Platteville Group is generally fossiliferous, containing a large and varied fauna. The Platteville Group was incorrectly correlated in early reports with the Trenton Limestone of New York. It is equivalent to the Lowville and Chaumont Formations of the Black River Group in New York, the upper part of the Stones River Group in Tennessee, the upper part of the High Bridge Group in Kentucky, and the Black River Limestone in Indiana and Michigan.

## Pecatonica Formation

The Pecatonica Formation (Hershey, 1894, p. 175; 1897), the basal formation of the Platteville Group, is named for exposures along the Pecatonica River north of

	Formation	Member	Graphic	Feet
			Column	
Plattin Subgroup	Quimbys Mill	Strawbridge		0 - 15
		Shullsburg		3 - 20
		Hazel Green		0 - 10
	Nachusa	Everett		0 - 25
		Elm		0 - 15
		Eldena		0 - 40
	Grand Detour	Forreston		2 - 40
		Victory		0 - 7
		Hely		3 - 73
		Clement		0 - 13
		Stillman		5 - 65
		Walgreen		0 - 12
	Mifflin	Dement		9 - 20
		Briton		3 - 55
		Hazelwood		1 - 50
		Establishment		2 - 8
		Brickeys		1 - 20
		Blomeyer		0 - 15
Pecatonica	Pecatonica	Oglesby		0 - 15
		Medusa		5 - 20
		New Glarus		5 - 25
		Dane		5 - 60
		Chana		0 - 20
		Hennepin		0 - 4

Fig. O-20—Columnar section of the Platteville Group (after Templeton and Willman, 1963).

the Illinois-Wisconsin state line. A section in the quarries and a roadcut on the East Branch of the Pecatonica River just north of Woodford, Lafayette County, Wisconsin (W 1/2 NW NE 14, 2N-5E), where it is 22.2 feet thick, has been designated the type section (Templeton and Willman, 1963, p. 73). The Pecatonica Formation overlies the Glenwood Formation or the St. Peter Sandstone in northern Illinois and the Joachim Dolomite in southern Illinois. It is overlain by the Mifflin Formation and is separated from both overlying and underlying units by sharp contacts that are at least regional diastems, perhaps uncon-

formities. In Illinois the Pecatonica Formation is exposed only in the northern area, but it is a distinctive unit widely recognized in subsurface (Buschbach, 1964). It is locally absent in northern Illinois over anticlines, in extreme western Illinois, and in the southern outcrop area north of Perry County, Missouri. It is commonly about 20 feet thick in northern Illinois, but it thickens to 150 feet in extreme southern Illinois. North of a line from southeastern Missouri, through north-central Illinois, and into northwestern Indiana, the Pecatonica Formation is mainly brown, finely vuggy dolomite in medium to thick beds and has large chert nodules at a few horizons. South of there it is largely brownish gray lithographic limestone mottled with dolomite. The Pecatonica is subdivided into six members: the Hennepin (at the base) varies but is generally dolomitic siltstone, the Chana is sandy, the Dane is argillaceous, the New Glarus is pure, the Medusa is weakly argillaceous and strongly fucoidal, and the Oglesby at the top is coarse calcarenite. The Pecatonica has a dominantly brachiopod-molluscan fauna but generally is less fossiliferous than the overlying Platteville formations. The Pecatonica is a widely distributed unit in the Mississippi Valley, and it is equivalent to the Ridley Formation in Tennessee and to the lower beds in the Lowville of New York.

**Hennepin Member**—The Hennepin Member of the Pecatonica Formation (Templeton and Willman, 1963, p. 75) is named for Hennepin County, eastern Minnesota. The type section is in a bluff on the west side of the Mississippi River at Lock and Dam No. 1 in Minneapolis (NE SW NW 17, 28N-23W), where the member is 2.3 feet thick. It varies from a dolomitic sandstone to a siltstone and to very sandy silty dolomite, which differentiates it from the relatively pure, although sandy, Chana Member above. It is locally present in extreme northern Illinois, where it is a dolomitic sandstone containing phosphate pebbles and is commonly 2-4 feet thick. It differs from the sandstone in the Glenwood Formation below in that it contains carbonates and its sands have a texture like that of the St. Peter. It appears in places to be a reworking of Glenwood sediments at the beginning of Platteville carbonate deposition.

**Chana Member**—The Chana Member of the Pecatonica Formation (Templeton and Willman, 1963, p. 76) is named for Chana, Ogle County, 9 miles east of the type section (ravine in W1/2 SE SE NE 24, 23N-9E), where it is 6.2 feet thick. In the northern outcrop area it is commonly less than 5 feet thick, but it reaches 20 feet in southern Illinois. In the northern area it is largely brown, thick-bedded, vuggy, pure dolomite that contains disseminated sand grains and, in places, thin beds of sandstone of the St. Peter texture. The basal part commonly has slightly argillaceous or shaly beds and phosphatic pebbles. In southern Illinois it is largely pure, thick-bedded limestone.

**Dane Member**—The Dane Member of the Pecatonica Formation (Templeton and Willman, 1963, p. 76) is named for Dane County, Wisconsin. The type section is a quarry and roadcut in Dane County, 4 miles north of New Glarus, Green County (SW NW NE 34, 5N-7E), where the member is 8.2 feet thick. The Dane Member commonly is 5-10 feet thick in the outcrop area, but it is as much as 60 feet in extreme southern Illinois. It consists of slightly argillaceous, partly cherty, brown dolomite or limestone in thin to medium beds separated by thin shale partings. The Dane is the most fossiliferous of the Pecatonica members, and it is characterized regionally by the abundance of *Opikina minnesotensis*.

**New Glarus Member**—The New Glarus Member of the Pecatonica Formation (Templeton and Willman, 1963, p. 77)

is named for New Glarus, Green County, Wisconsin, and the type section is in the same section as the Dane Member. The New Glarus is 5.7 feet thick at the type section, is generally about 5 feet thick in the northern outcrop area, and thickens to 25 feet in extreme southern Illinois. It is dolomite in northern Illinois and limestone in southern Illinois and is relatively pure, thick bedded, and locally cherty.

**Medusa Member**—The Medusa Member of the Pecatonica Formation (Templeton and Willman, 1963, p. 77) is named for the Medusa Cement Company plant, 2 miles northeast of Dixon, Lee County, which is 1.5 miles south of the type section, a quarry on the east side of the Rock River Valley (SW SW NW 22, 22N-9E), where the member is 5.2 feet thick. In the northern outcrop area it is commonly 5-7 feet thick, but it thickens to 20 feet in extreme southern Illinois. In the outcrop area it consists of dolomite or of limestone heavily mottled with dolomite. It is slightly argillaceous, very fucoidal, and thick bedded to massive. South of Ogle County it contains chert nodules.

**Oglesby Member**—The Oglesby Member of the Pecatonica Formation (Templeton and Willman, 1963, p. 77) is named for Oglesby, La Salle County, and the type section is in Matthiessen State Park east of Oglesby (NE NE NE 31, 33N-3E), where the member is 12 feet thick. It is absent in Illinois north of the type locality, but it is as much as 15 feet thick in southern Illinois. It is pure, light gray, white, or buff calcarenite that is laminated, rarely conglomeratic, and locally cross bedded. It is medium to coarse grained in the type locality but fine grained elsewhere. A strong iron-stained corrosion surface occurs on the top and is equivalent to a similar surface on the top of the Medusa Member in northern Illinois, where the Oglesby is absent.

### *Plattin Subgroup*

The Plattin Subgroup (Ulrich, 1904, p. 111; Weller and St. Clair, 1928, p. 109-110) is named for Plattin Creek, Jefferson County, Missouri, near the mouth of which it is partially exposed. As originally defined, it included strata equivalent to the Decorah at the top but not the Pecatonica below. Weller and St. Clair removed the Decorah, and, as thus defined, the Plattin was long considered equivalent to the Platteville in northern Illinois. Because the Plattin did not include the Pecatonica Formation of the Platteville Group (the Pecatonica is not present in the Plattin Creek area), the Plattin was reclassified as a subgroup (Templeton and Willman, 1963, p. 78). The Plattin is a distinctive unit, particularly in the northern outcrop area and in other regions where it is dominantly fine-grained and lithographic limestone, separated by a minor unconformity from the dolomitic Pecatonica Formation below. The Plattin Subgroup includes the Mifflin (at the base), Grand Detour, Nachusa, and Quimbys Mill Formations. The Plattin Formation, as defined in Missouri, consists of the strata from the oolite in the Brickeys Member of the Mifflin Formation to the base of the Decorah Formation. The Plattin Subgroup is equivalent to the McGregor Formation in the Upper Mississippi Valley

above Dubuque, Iowa, except in the lead-zinc district where the McGregor has been redefined to exclude the Quimbys Mill Formation (Agnew and Heyl, 1946).

### *Mifflin Formation*

The Mifflin Formation (Bays, 1938, p. 269) is named for Mifflin, Iowa County, Wisconsin, just west of the type section, a roadcut and bluff on the east side of the Pecatonica River (NE NE NE 34, 5N-1E), where it is 17.8 feet thick. The Mifflin is a widespread, thin-bedded, relatively shaly limestone overlying the thick-bedded, generally more dolomitic Pecatonica Formation and underlying the medium-bedded, less shaly Grand Detour Formation. It is exposed widely in north-central Illinois and in a small area at West Point Landing in Calhoun County (fig. O-2D). It is commonly 15-25 feet thick in the northern area, but it thickens to 120 feet in subsurface in southern Illinois. The Mifflin Formation is dominantly gray, lithographic limestone, most of it thin bedded and shaly. Locally it grades to shaly fine-grained dolomite in the northern outcrop area and to sandy shale and sandstone in extreme western Illinois. The shale partings in the Mifflin are gray to green, in contrast to the generally brownish gray to red-brown partings in the Grand Detour. In the northern outcrop area the Mifflin is characterized by a persistent, massive, middle unit, and in Calhoun County and farther south it has a distinctive oolite in the lower part that is widely recognized in subsurface. The oolite forms the top of the Rock Levee Formation in Missouri. The Mifflin is differentiated into five members: the Blomeyer (at the base), is argillaceous; the Brickeys is pure; the Establishment is argillaceous; the Hazelwood is pure; and the Briton (at the top) is argillaceous. In the northern outcrop area the Blomeyer, Brickeys, and Establishment Members are thin and differ only slightly in clay content. Where these units are not differentiated, they are combined as the lower shaly unit and assigned to the Establishment Member. The Mifflin then consists of a three-fold (shaly, massive, shaly) sequence. The Mifflin is the most fossiliferous formation in the Platteville Group, containing an abundant and varied brachiopod, molluscan, and bryozoan fauna. It is the lower, shaly part of the McGregor Limestone north of Illinois, and is correlated with strata in the upper part of the Camp Nelson Formation in Kentucky, the lower part of the Lebanon Limestone in Tennessee, and with the upper part of the lower division of the Lowville Limestone in New York.

**Blomeyer Member**—The Blomeyer Member of the Mifflin Formation (Templeton and Willman, 1963, p. 80) is named for Blomeyer, Cape Girardeau County, Missouri, about 6 miles southwest of the type section, which is a small quarry a quarter of a mile east of the highway junction at Rock Levee (NW cor. NE NW 24, 30N-13E), where the member is 12.1 feet thick. The Blomeyer is irregularly present, but it is as much as 15 feet thick in subsurface in southern Illinois. It is less than a foot to 3 feet thick in the northern outcrop area. The Blomeyer consists of argillaceous, fine-grained limestone, or locally dolomite, that weathers thin-bedded to shaly.

**Brickeys Member**—The Brickeys Member of the Mifflin Formation (Templeton and Willman, 1963, p. 81) is named for Brickeys, Ste. Genevieve County, Missouri, which is 3 miles east of the type section, a quarry on the east side of

Missouri Highway 25 (SE SW SE 28, 39N-7E), where the member is 15.5 feet thick. The Briceys Member is commonly 13-20 feet thick in the outcrop area in Missouri but is as much as 40 feet thick in subsurface in southern Illinois. Where locally differentiated in the northern outcrop area, it is 1-2 feet thick. In the southern area much of the Briceys Member is relatively pure, brown, lithographic limestone, but it contains a few beds of gray to buff, argillaceous limestone and dolomite. Several beds are strongly oolitic; others are a fine conglomerate or breccia. The member also contains a few beds of green shale as much as 5 inches thick, domes of *Stromatocerium*, several scour surfaces with a relief of 2-8 inches, and, in one locality, a thin bentonite near the base. The shale beds are persistent from Calhoun County, Illinois, to Ste. Genevieve County, Missouri, but elsewhere the unit is dominantly a relatively pure limestone containing oolite beds. In the northern outcrop area the Briceys is relatively pure but not oolitic.

**Establishment Member**—The Establishment Member of the Mifflin Formation (Templeton and Willman, 1963, p. 82) is named for Establishment Creek in Ste. Genevieve County, Missouri. The type section is an exposure in a tributary ravine just north of the village of Zell (W $\frac{1}{4}$  34, 38N-8E), where the member is 5.5 feet thick. The Establishment Member is 2-8 feet thick in southern Illinois, where it is a green shale with thin interbeds of argillaceous, chalky limestone. The shale facies appears to be limited to a region bordering the Ozarks and is a persistent marker bed; elsewhere the member is thin-bedded, shaly, brown lithographic limestone. In the northern area it is limestone, commonly about 5 feet thick, and is gray, dolomite mottled, argillaceous, thin bedded, and shaly. It contains a few thin beds of calcarenite.

**Hazelwood Member**—The Hazelwood Member of the Mifflin Formation (Templeton and Willman, 1963, p. 82) is named for Hazelwood School, Lee County, 2 miles west of the type section, a quarry on the east side of the Rock River Valley 3.5 miles north of Dixon (SW SW NW 22, 22N-9E), where it is 5.7 feet thick. The Hazelwood Member is widespread, but it is missing in Calhoun County. It is commonly 4-6 feet thick in the northern outcrop area, but it thickens southward and, judging from exposures near Cape Girardeau, Missouri, is probably as much as 50 feet thick in subsurface in southern Illinois. In the northern outcrop area, the Hazelwood is relatively pure, gray, thick-bedded to massive, lithographic limestone generally dolomite mottled, fucoidal, and with few fossils. A ferruginous corrosion surface occurs on the top. In the southern area, the Hazelwood is relatively pure, brown, fucoidal, fine-grained limestone, thicker bedded than the members above and below.

**Briton Member**—The Briton Member of the Mifflin Formation (Templeton and Willman, 1963, p. 83) is named for Briton School, 2 miles northeast of Dixon and 1.5 miles southwest of the type section, which is in the same quarry as the Hazelwood type section. The Briton is 10 feet thick in the type section. It is the uppermost shaly member of the Mifflin and is widely present. It is 3-12 feet thick in the northern outcrop area, but it thickens southward to as much as 55 feet in the southern outcrop area in Missouri and probably has a comparable thickness in subsurface in southern Illinois. In the northern outcrop area it is largely light gray, white-weathering, fossiliferous, lithographic, argillaceous limestone in thin wavy beds that have strong green shale partings. It grades to dolomite in a few places. In the southern area it is less argillaceous and only slightly shaly but is distinctly more impure than adjoining members.

## Grand Detour Formation

The Grand Detour Formation (Templeton and Willman, 1963, p. 83) is named for Grand Detour, Ogle County,

which is 3 miles east of the type section, a quarry in the west bluff of the Rock River, on the Walgreen estate 2 miles north of Dixon (NE 20, 22N-9E), where it is 52.3 feet thick. The Grand Detour Formation extends throughout most of Illinois, overlying the Mifflin Formation, underlying the Nachusa Formation, and conformable with both. It is generally about 50 feet thick in the northern outcrop area and in exposures in Calhoun County (fig. O-2D), but it thickens southward in subsurface to about 210 feet in southern Illinois. That it thickens rapidly south of Randolph County is suggested by the near-by exposures in Missouri. The Grand Detour consists largely of dolomite-mottled, lithographic, slightly argillaceous to pure limestone that contains thin beds of calcarenite; in places it is fine- to medium-grained dolomite. Most of it is medium bedded, with thin, brown-red, dark gray, or black shale partings, but it contains persistent units that are thick bedded to massive, fucoidal, and pure. The Dement Member (at the base) is pure; the Walgreen is argillaceous or shaly; the Stillman is pure, fucoidal, and massive; the Clement is calcarenite; the Hely is argillaceous; the Victory is pure and white or very light gray; and the Forrester (at the top) has alternating pure and argillaceous beds with red-brown shaly partings. Scour and corrosion surfaces occur between and within some of the members. The Grand Detour is generally fossiliferous, having a varied brachiopod-molluscan fauna and several species of corals, among which *Lambeophyllum* and *Tetradiem* are particularly common. The medium bedding and the dark, generally red-brown, shale partings distinguish the Grand Detour from the Mifflin below with its thin beds and green shale partings, and from the Nachusa above, which is purer, more uniform, and thick bedded to massive. The Grand Detour is the upper part of the McGregor Limestone north of Illinois and is equivalent to strata in the upper part of the Camp Nelson Formation, the Oregon Formation, and the lower part of the lower member of the Tyrone Formation in Kentucky, the upper part of the Lebanon Formation in Tennessee, and the upper part of the Lowville Limestone in New York.

**Dement Member**—The Dement Member of the Grand Detour Formation (Templeton and Willman, 1963, p. 84) is named for Dement Avenue in Dixon, Lee County, 2 miles south of the type section (part of the Grand Detour type section), where the Dement is 8 feet thick. The Dement Member is generally 3-8 feet thick in the northern outcrop area and in the Calhoun County exposures, but it thickens southward to 20 feet in the Cape Girardeau area. In northern Illinois it is relatively pure, dolomite-mottled, gray, lithographic, thick-bedded limestone, but locally it is fine-grained dolomite. It contains a few thin calcarenitic layers and a few scattered chert nodules. In the southern area it is brown, fucoidal, and only locally cherty, but near St. Louis it is a conglomeratic, vuggy, very fine-grained calcarenite.

**Walgreen Member**—The Walgreen Member of the Grand Detour Formation (Templeton and Willman, 1963, p. 85) is named for the Walgreen estate, on which the type section (part of the Grand Detour type section) occurs. The Walgreen Member is 8.3 feet thick in the type section and is generally 5-10 feet thick in the outcrop areas in northern Illinois and eastern Missouri. Most of it is gray, thin- to medium-bedded, argillaceous, shaly limestone that contains disseminated fossil debris and thin beds of purplish gray calcarenite. In the southern outcrop area it is brown, thicker bedded, and less argillaceous than in northern Illinois.

**Stillman Member**—The Stillman Member of the Grand Detour Formation (Templeton and Willman, 1963, p. 85) is

named for Stillman's Run, a stream 1.5 miles east of the type section, which is a quarry just north of Byron, Ogle County (NE NE SE 30, 25N-11E), where it is 5.3 feet thick. The member is 5-8 feet thick in the northern outcrop area, but in the southern outcrop area it thickens from 5 feet in Calhoun County to 64 feet at Cape Girardeau, Missouri. The Stillman Member consists of dolomite-mottled, lithographic limestone, or, in places, vuggy, fine- to medium-grained dolomite. It is generally pure, cherty, fucoidal, and thick bedded or massive. In the southern area it is divisible into an upper fucoidal unit, a middle argillaceous to shaly, partly cherty unit, and a basal calcarenitic fucoidal unit.

**Clement Member**—The Clement Member of the Grand Detour Formation (Templeton and Willman, 1963, p. 86) is named for Clement Station, Ste. Genevieve County, Missouri, which is 7 miles north of the type section in a ravine 0.5 mile north of the village of Zell (W $\frac{1}{4}$  34, 38N-8E), where it is 13 feet thick. The Clement Member is only 1-4 inches thick where locally present in the northern outcrop area. It is 6 feet thick in outcrops near Cape Girardeau. The Clement consists of purplish gray, medium- to coarse-grained calcarenite. Where thick it occurs in 2-15 inch beds that are locally cross bedded. It grades to calcarenitic limestone in some areas.

**Hely Member**—The Hely Member of the Grand Detour Formation (Templeton and Willman, 1963, p. 86) is named for Hely's upper quarry on the south side of Cape Girardeau, Missouri, which, with the adjoining Federal and Marquette quarries is the type section (NW NE and SE NW 18, 30N-14E). It is 3-5 feet thick in the northern Illinois outcrop area and 5-8 feet in the northern part of the southern outcrop area, but south of Ste. Genevieve it thickens rapidly, and in the type section it is 73 feet thick. The Hely Member consists of argillaceous, lithographic limestone in thin to medium beds with thin shale partings. Much of the member is calcarenitic or contains thin calcarenite layers. It is locally cherty and generally not fucoidal.

**Victory Member**—The Victory Member of the Grand Detour Formation (Templeton and Willman, 1963, p. 86) is named for Mt. Victory School, Calhoun County, 4.5 miles north of the type section, a quarry north of West Point Landing (SE NE SE 19, 7N-2W), where it is 5.5 feet thick. The Victory Member is commonly only a foot or less thick in the northern outcrop area but is 3 feet thick in La Salle County, and in the southern outcrop area it ranges from 3.5 feet near St. Louis to 7 feet at Cape Girardeau. The Victory Member is a distinctive, white to light gray lithographic limestone containing calcite flecks that give it the "bird's-eye" appearance typical of limestones equivalent to Platteville limestones in other regions. Many of the calcite flecks are fillings of corallites of *Tetradium*. The Victory Member is massive to thick bedded and locally contains a little chert. In northern Illinois it locally grades to light gray, white-weathering dolomite, and it is not as distinctive as it is in the southern area, where it is the most easily identified member of the Platteville Group. Although generally absent north of Illinois, beds similar to the Victory occur in Kentucky, Tennessee, and New York.

**Forreston Member**—The Forreston Member of the Grand Detour Formation (Templeton and Willman, 1963, p. 87) is named for Forreston, Ogle County, which is 7 miles northeast of the type section, a quarry in Carroll County on the north side of a ravine 1 mile northwest of Brookville (NE SE NW 21, 24N-7E), where it is 17.9 feet thick. The Forreston Member is commonly 5-25 feet thick in the northern outcrop area and in the northern part of the southern outcrop area, but it thickens southward to 40 feet at Cape Girardeau. It consists largely of dolomite-mottled lithographic limestone or fine-grained dolomite. It is commonly fossiliferous. In many exposures it can be differentiated into three cyclical units, each

consisting of a thin-bedded, shaly unit at the base and a thicker bedded, purer unit at the top. The shaly units generally contain the thickest red-brown shale partings in the Grand Detour. The member contains some chert, and thin beds of calcarenite are common. In subsurface in west-central Illinois, a sandy zone about 5 feet thick is present at or near the base.

## Nachusa Formation

The Nachusa Formation (Templeton and Willman, 1963, p. 87), which overlies the Grand Detour Formation, is named for the village of Nachusa, Lee County. The type section is a quarry on the east edge of Dixon (SE SE SW 33, 22N-9E), where the Nachusa is 17.8 feet thick. It is 15-20 feet thick in the northern part of the southern outcrop area, but south of Ste. Genevieve in the Cape Girardeau area it thickens rapidly to 75 feet. It thins to less than 5 feet in subsurface in central western and extreme northwestern Illinois. The Nachusa consists largely of fine- to medium-grained, vuggy dolomite in northern Illinois (fig. O-2F) and dolomite-mottled lithographic limestone in the southern area (fig. O-2D). It is pure to slightly argillaceous, cherty, fucoidal, and thick bedded to massive. The weathered surface is deeply etched. In parts of northern Illinois the Nachusa resembles the dolomite of the Galena Group, and in some areas it has been miscorrelated with the Galena. In the southern outcrop area it contains layers of bentonite, calcarenite, and conglomeratic limestone. A persistent argillaceous and thin-bedded zone in the Nachusa is used to subdivide the formation into three members; the Eldena (at the base) is thick bedded and slightly argillaceous; the Elm is thin bedded and argillaceous; and the Everett (at the top) is massive and pure. The Nachusa is moderately fossiliferous; corals, brachiopods, and gastropods are the most common fossils. In the northern area, the Nachusa is characterized by the abundance of *Foerstephyllum halli*, but a few specimens also are found in upper Grand Detour strata. *Foerstephyllum* is present but not common in the southern outcrop area. The Nachusa has a sharp contact with the overlying Quimbys Mill Formation but a gradational contact with the Grand Detour below. The Nachusa is absent in the Mississippi Valley northwest of Illinois, but it occurs in northern Michigan. It is correlated with the Chaumont Formation of New York and Ontario because of striking similarities in fauna and lithology, with the upper part of the lower member of the Tyrone Formation in Kentucky, and with the lower member of the Carters Limestone in Tennessee.

**Eldena Member**—The Eldena Member of the Nachusa Formation (Templeton and Willman, 1963, p. 89) is named for Eldena, Lee County, 6 miles southeast of the type section (part of the Nachusa type section), where it is 7.5 feet thick. It is commonly 5-10 feet thick in the northern outcrop area and in Calhoun County, but south of there it thickens to 14 feet in Ste. Genevieve County, Missouri, and to 40 feet at Cape Girardeau, Missouri. It has the typical Nachusa lithology, except that the lower part has thin partings of blue-gray to gray-green or brown shale, and it is slightly more argillaceous than the Everett Member. In the southern area it contains finely conglomeratic and pseudo-oolitic beds, and a bentonite as much as 6 inches thick occurs at or near the top. It is equivalent to the Leray Member of the Chaumont Formation in New York.

**Elm Member**—The Elm Member of the Nachusa Formation (Templeton and Willman, 1963, p. 89) is named for Elm

Street in Dixon, Lee County, just southwest of the type section (part of the Nachusa type section), where the member is 2.8 feet thick. It is widely present, but it is absent in subsurface in western Illinois. It is 1-4.5 feet thick in the northern outcrop area, is 7 feet thick in Calhoun County and near Ste. Genevieve, Missouri, and it thickens southward to 15 feet at Cape Girardeau. It consists of argillaceous, gray, cherty dolomite or limestone and is mainly nonfucoidal. It is thin bedded and has thin shale partings. It commonly weathers to a smooth surface, which distinguishes it from the members above and below that have pitted surfaces. It is equivalent to the Glenburnie Member, a similar shaly unit, in the Chaumont Formation in New York.

**Everett Member**—The Everett Member of the Nachusa Formation (Templeton and Willman, 1963, p. 90) is named for Everett Street in Dixon, Lee County, near the type section (part of the Nachusa type section), where the member is 7.5 feet thick. It averages about 7 feet thick in the northern outcrop area, and is commonly about 20 feet thick in the southern area. The Everett has the typical Nachusa lithology, differing from the Eldena Member in being more massive, very abundantly fucoidal, and generally purer. At the top of the member there is a distinctive bed of fine-grained, dense dolomite or limestone 3-8 inches thick that has a smooth, white-weathering surface and overlies a band of very large chert nodules. A thin bed of bentonite occurs 8-9 feet below the top in the southern outcrop area. The Everett is equivalent to the Watertown Member of the Chaumont Formation in New York.

## Quimby's Mill Formation

The Quimby's Mill Formation (Agnew and Heyl, 1946, p. 1585), which overlies the Nachusa Formation, is named for Quimby's Mill near Etna, Lafayette County, Wisconsin (SE SE 11, 1N-1E) (Templeton and Willman, 1963, p. 235). The type section is a small quarry near the mill where the formation is 12 feet thick. The Quimby's Mill is close to 12 feet thick throughout the northern outcrop area in Illinois and 30-35 feet thick in the southern outcrop area in Illinois and Missouri, but it locally thins in subsurface and in Sangamon County is only 3 feet thick. In the type area and in a small exposure in extreme northwestern Illinois, the Quimby's Mill is brown lithographic limestone with brown shale partings. Because of its pronounced conchoidal fracture it is known as the "Glassrock." In the outcrop area in central northern Illinois, it is light brown, dense, very fine-grained, slightly argillaceous dolomite that weathers yellow-buff (fig. O-2F). It is thin to medium bedded and has thin brown shale partings. In the southern outcrop area the formation is fine-grained to lithographic limestone, the shale partings are greenish gray, the bedding and weathered surfaces are relatively smooth, and it contains some thin layers of conglomerate, fossil debris, and bentonite. The Quimby's Mill Formation is differentiated into three members; the Hazel Green (at the base) is thick bedded, slightly shaly, and weathers white; the Shullsburg is thin bedded and shaly; and the Strawbridge (at the top) is thick bedded, slightly shaly, and finely fucoidal. The Quimby's Mill is generally fossiliferous, containing brachiopods (especially *Strophomena*), bryozoans, horn corals, trilobites, and the ostracode *Eoleperditia*. The Quimby's Mill has a sharp contact, probably a diastem, with the underlying Nachusa, and its top is a ferruginous, pitted surface that is a regional unconformity with low relief. The Quimby's Mill is overlain by the Spechts Ferry

Formation, the basal formation of the Galena Group, in extreme northwestern Illinois and in Calhoun County, but the Spechts Ferry thins out eastward and is not present in the northern outcrop area or in subsurface in eastern Illinois, where the Guttenberg Formation overlies the Quimby's Mill Formation. The Quimby's Mill extends eastward into Ontario, but it appears to be absent in the New York section. It is equivalent to the upper member of the Tyrone Formation in Kentucky and the upper member of the Carters Limestone in Tennessee.

**Hazel Green Member**—The Hazel Green Member of the Quimby's Mill Formation (Templeton and Willman, 1963, p. 91), the basal member, is named for Hazel Green, Grant County, Wisconsin, 6 miles southwest of the type section (part of the Quimby's Mill type section), where the Hazel Green is 1.7 feet thick. It is as much as 2.5 feet thick in the northern outcrop area in Illinois and 10 feet in the southern outcrop area at Cape Girardeau, Missouri. The Hazel Green Member consists of lithographic limestone or fine-grained dolomite, mainly pure and thick bedded. It has a smooth, light buff to white, weathered surface. A bentonite at the base near Cape Girardeau extends as far north as Lincoln County, Missouri.

**Shullsburg Member**—The Shullsburg Member of the Quimby's Mill Formation (Templeton and Willman, 1963, p. 92), which overlies the Hazel Green Member, is named for Shullsburg, Lafayette County, Wisconsin, 5 miles east of the type section (part of the Quimby's Mill type section), where the Shullsburg is 2.5 feet thick. It is as much as 5 feet thick in the northern outcrop area in Illinois and 7 feet in Calhoun County, but it thickens to about 20 feet near St. Louis and commonly is about 15 feet thick in outcrops south of there. The Shullsburg consists of brown to buff, slightly argillaceous, lithographic limestone or fine-grained dolomite. It is thin to medium bedded, strongly shaly in the north, but only slightly shaly in the southern outcrop area. In Missouri it contains some white, "glassy" beds. In northern Illinois the bedding surfaces at some places are mud-cracked or ripple-marked.

**Strawbridge Member**—The Strawbridge Member at the top of the Quimby's Mill Formation (Templeton and Willman, 1963, p. 92) is named for Strawbridge, Lafayette County, Wisconsin, 3 miles southwest of the type section (part of the Quimby's Mill type section), where the Strawbridge is 7.8 feet thick. It is about 7 feet thick in the northern outcrop area in Illinois and 10-15 feet thick in the southern outcrop area. It is similar in lithology to the Shullsburg Member but is less argillaceous, generally thicker bedded, and has fewer and thinner shale partings. It is partly cherty, especially at the top, in northern Illinois. It contains numerous fucoids, which are scarce in the older members of the formation and much smaller than those in the underlying Nachusa Formation.

## Trentonian Stage

The Trentonian Stage (Vanuxem, 1838, p. 257, 276, 283; Kay, 1948, p. 1411), named for Trenton Falls in New York State, is represented in Illinois by the strata of the Galena Group. These rocks are present throughout most of Illinois (fig. O-21). They are correlated with the type Trentonian of New York on the bases of both faunal and lithologic similarity (Templeton and Willman, 1963). Trentonian strata are generally fossiliferous and the fauna contains many forms not found in

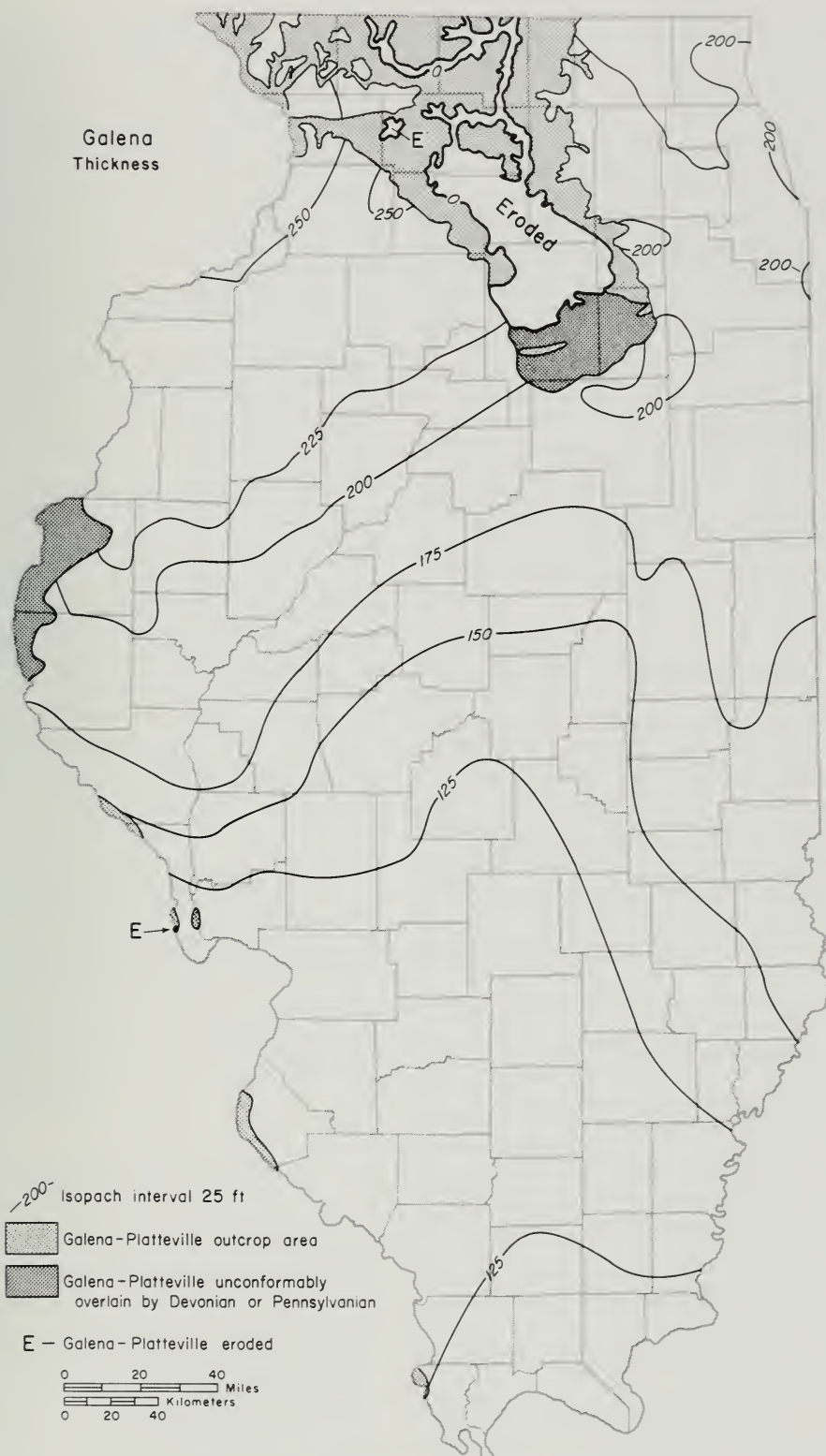


Fig. O-21—Thickness of the Galena Group.

the Blackriveran below or the Cincinnati above.

### Galena Group

The Galena Group (Hall, 1851, p. 146-148; Kay, 1935b, p. 289; Templeton and Willman, 1963, p. 93) consists of limestone and dolomite formations overlying the Platteville Group and underlying the Maquoketa Group of the Cincinnati Series. The Galena Group is named for Galena in Jo Daviess County, and several sections in the vicinity of Galena have been designated the type section. Hall put the base of the Galena in the Decorah Subgroup, either at the top or the base of the Guttenberg Formation; Kay raised it to the top of the Decorah; and Templeton and Willman lowered it to the base of the Decorah, which is the present usage in Illinois. The Galena Group is present in all of Illinois (fig. O-21) except (1) the areas where the older rocks are exposed in central northern Illinois and in Calhoun County and (2) an area along the crest of the La Salle Anticline, largely in La Salle County, where Galena strata were eroded before deposition of the Pennsylvanian rocks. The Galena is extensively exposed in northern Illinois (fig. O-2B, C), but elsewhere it crops out only in small areas on anticlinal structures in Calhoun, Monroe, and Alexander Counties. The Galena Group is 250-275 feet thick in the northern outcrop area, but the upper part is truncated by the Cincinnati Series in central Illinois, and south of there the group is only 100-125 feet thick. The group is divided into two subgroups (fig. O-22)—the Decorah at the base is a shaly unit and the Kimmswick above it is relatively pure limestone and dolomite. The shaly Dubuque Formation, although included as the top of the Galena Group in northwestern Illinois, is not included in the Kimmswick Subgroup. The Galena Group has three major facies (fig. O-23). A fine-grained limestone facies is present only in extreme northwestern Illinois, where as much as 50 feet of limestone at the base of the group changes rapidly to dolomite southward and eastward. In most of northern Illinois, the group is entirely dolomite. Southward, the lower part becomes limestone, and a short distance south of La Salle only the uppermost part is dolomite. The lower part is largely coarse calcarenite, overlain by fine-grained limestone. Still farther south, the fine-grained limestone is truncated so that the group is entirely calcarenite and calcarenitic limestone. Galena Group strata are generally fossiliferous (fig. O-5), but fossils are poorly

	Formation	Member	Graphic Column	Feet
Kimmswick Subgroup	Dubuque			
		0-45'		
	Wise Lake	Stewartville		30-35
		Sinsinowo		35-40
	Dunleith	Wyota		18-20
		Wall		10-12
		Sherwood		10-15
		Rivoli		13-20
		Mortimer		10-13
		Fairplay		14-20
		Eagle Point		9-18
		Beecher		8-15
		St. James		8-28
		Buckhorn		0-8
Decorah Subgroup	Guttenberg	Glenhaven		0-12
		Garnaville		0-4
	Kings Lake	Tyson		0-8
		Mincke		0-6
	Spechts Ferry	Glencoe		0-15
		Castlewood		0-7

Fig. O-22—Columnar section of the Galena Group (after Templeton and Willman, 1963).

preserved in the dolomite facies. *Receptaculites oweni*, an alga (fig. O-5), is perhaps the most characteristic fossil, but several zones characterized by abundance of certain species of brachiopods and bryozoans are persistent (fig. O-24). The Galena Group is equivalent to the Trenton Group of New York, the Lexington Limestone of Kentucky, and the Nashville Group of Tennessee.

## Decorah Subgroup

The Decorah Subgroup (Calvin, 1906, p. 84; Kay, 1935b, p. 289; Herbert, 1949) consists of the shaly limestone and dolomite formations at the base of the Galena Group. It is named for exposures at Decorah, Winneshiek County, Iowa. At Decorah it is called the Decorah Formation and includes the Spechts Ferry, Guttenberg, and Ion Members. Kay took the Spechts Ferry out of the Decorah and put it in the Platteville, but Herbert showed that the Spechts Ferry belonged in the Decorah. Templeton and Willman (1963) removed the strata equivalent to the Ion from the Decorah in Illinois because they are not shaly. The Decorah is extensive in Illinois and is exposed in central northern and extreme northwestern Illinois in a small area near West Point Landing in Calhoun County, and at Valmeyer in Monroe County. It is 15-30 feet thick in western Illinois, but it thins eastward and is generally only 1-5 feet thick in the central and eastern parts of the state. The Decorah consists of three formations—the Spechts Ferry (at the base) is green shale and limestone; the overlying Kings Lake is largely limestone, partly silty and sandy; and the Guttenberg (at the top) is limestone with beds of brown-red shale. The Kings Lake thins out northward and is not present in northern Illinois. Both the Kings Lake and the Spechts Ferry thin out eastward, and in central and eastern Illinois the Decorah consists only of the Guttenberg Formation. The Decorah strata in Illinois are very fossiliferous, containing abundant bryozoans and brachiopods. *Refinesquina*, *Sowerbyella*, and *Pionodema* (fig. O-5) are especially abundant. Decorah strata in Illinois correlate with the Rockland Formation in New York, the Curdsville and Logana Members of the Lexington Limestone in Kentucky, and the lower part of the Hermitage Limestone in Tennessee.

## Spechts Ferry Formation

The Spechts Ferry Formation (Kay, 1928, p. 16; 1935b, p. 287) consists of as much as 15 feet of interbedded shale and limestone. It is the basal formation of the Galena Group, underlying the Kings Lake or Guttenberg Formations and unconformably overlying various Platteville formations. The type section is in a ravine at Spechts Ferry, Dubuque County, Iowa (SW NW 4, 90N-2E), where it is 7.8 feet thick (Agnew et al., 1956, p. 307; Templeton and Willman, 1963, p. 106). The Spechts Ferry Formation is exposed in northwestern Illinois along the Galena River in Jo Daviess County (cen. 34, 29N-1E) and in small areas near West Point Landing in Calhoun County, and Valmeyer, Monroe County. It is

commonly 5-10 feet thick in wells in western Illinois but is absent in the central and eastern parts of the state. Limestone is dominant in the south and shale in the north. Much of the shale is bright green, but it is locally greenish gray and the basal few inches is dark brown. The formation is characterized by two bentonites and by the persistence of distinctive thin beds of dense, fine-grained to earthy limestone, coquinite, and dark purplish gray, coarse-grained calcarenite. It is subdivided into the Castlewood Member (at the base), which is dominantly limestone, and the Glencoe Member (at the top), which is limestone and shale—in places dominantly shale. In the mining district in northwestern Illinois, it is called the "Clay bed." *Pionodema subaequata* (fig. O-5) is abundant in the Spechts Ferry. Other Trentonian fossils are common, particularly bryozoans (Perry, 1962). The Spechts Ferry Formation is the *Stictoporella* bed of early reports. It rests on a distinctive, pitted, ferruginous, and phosphatic surface on the top of the Quimbys Mill Formation, and the basal beds locally contain fragments of that formation. In northwestern Illinois, where the Kings Lake is absent, the Spechts Ferry is overlain by the Guttenberg Formation, the basal beds of which contain phosphate nodules. The Spechts Ferry Formation is correlated with the Selby Member of the Rockland Formation in New York and the Curdsville Limestone in Kentucky and Tennessee.

**Castlewood Member**—The Castlewood Member of the Spechts Ferry Formation (Templeton and Willman, 1963, p. 107), the basal member, is largely limestone in its type section near Castlewood, St. Louis County, Missouri (NE SE SE 21, 44N-4E), where it is 6.9 feet thick. It is a massive bed 3-7 feet thick in the type region, but it is only a few inches to 1.5 feet thick in northwestern Illinois. The limestone commonly overlies a thin bentonite, generally less than an inch thick, which rests on dark brown shale up to 3 inches thick. The limestone is fine grained, slightly argillaceous, and more like limestone beds in the Glencoe Member above than the pure lithographic limestone of the Platin below, from which it is separated by a widespread unconformity. Fossils are not abundant, but *Pionodema subaequata* and other Trentonian fossils are present. It has been called the *Lingula elderi* bed in Minnesota, where it is equivalent to the lower part of the Carimona Limestone (Weiss, 1955).

**Glencoe Member**—The Glencoe Member of the Spechts Ferry Formation (Templeton and Willman, 1963, p. 110), which overlies the Castlewood Member, is named for Glencoe, St. Louis County, Missouri, which is 3 miles west of the type section, the same as that for the Castlewood Member, where the Glencoe is 5.3 feet thick. It is commonly 5-8 feet thick in the area near the Mississippi River, but it thins to the east. The most persistent and thickest Ordovician bentonite, commonly 1-3 inches thick and locally as much as 8 inches thick, occurs in the lower part of the Glencoe Member, interbedded with green, gray, or brown shale. Locally the bentonite is altered to a distinctive, hard, pink bed, which is almost entirely potash feldspar. The Glencoe is largely green shale, but it contains beds of calcarenite, greenish gray argillaceous limestone, and dark purplish gray coarse-grained limestone. Some beds are a coquina of *Pionodema subaequata*. In the Upper Mississippi Valley, the trilobite *Isotelus gigas* (fig. O-5) is common in an argillaceous limestone bed near the base.

## Kings Lake Formation

The Kings Lake Formation (Herbert, 1949; Templeton and Willman, 1963, p. 110) overlies the Spechts Ferry



where the formation is 16.5 feet thick (Templeton and Willman, 1963, p. 236). The Guttenberg Formation is widely present in Illinois, and it is exposed in the localities described in the Decorah discussion. It is about 15 feet thick in the northwestern Illinois outcrop area and is 10-15 feet thick in southwestern Illinois. It thins eastward and is 3-5 feet thick in the outcrop area in central northern Illinois. In subsurface elsewhere it is only 1-3 feet thick and locally is missing. On the flanks of the Ozarks it is thinned and cut out in some localities by overlap of the Dunleith Formation. In the western part of Illinois, the Guttenberg consists of thin-bedded, tan, white-weathering, very fine-grained limestone interbedded with brown-red shale. Eastward it grades to brown, white-weathering, medium-grained, vuggy dolomite containing thin beds of brown-red shale. The dolomite facies is well exposed in the central northern outcrop area. The lower part, which is grayer, more argillaceous, and less shaly than the upper part, is differentiated as the Garnavillo Member, and the upper part is the Glenhaven Member. A thin but widely present bentonite occurs in a shale at the base of the Glenhaven. In the northwestern Illinois mining district the Guttenberg is locally thinned by solution of the limestone beds, largely in and close to the ore bodies, leaving a residue of brown-red shale called the "oilrock," which is only 2-4 feet thick. The reddish color of the Guttenberg is in part due to the abundance of minute resinous particles, probably the spores of algae. The Guttenberg has an abundant and varied fauna of

brachiopods, bryozoans, mollusks, and, in places, a few trilobites. *Sowerbyella* (fig. O-5) is most abundant in the Guttenberg, which includes the *Rhinidictya* and *Ctenodonta* beds of early reports. The Guttenberg Formation is equivalent to the Napanee Member of the Rockland Formation in New York, the upper part of the Logana Formation in Kentucky, and the middle part of the Hermitage Formation in Tennessee.

**Garnavillo Member**—The Garnavillo Member of the Guttenberg Formation (Templeton and Willman, 1963, p. 113), the lower member, is named for Garnavillo, Clayton County, Iowa, 7.5 miles northwest of the type section in the roadcut of U.S. Highway 52 on the northwest side of Guttenberg (SW SW 5, 92N-2W), where the member is 1.7 feet thick. The Garnavillo is present throughout most of the area where Guttenberg strata occur, but it does not extend as far east as the overlying Glenhaven Member. It is 2-3 feet thick in southwestern Illinois. It consists of gray to gray-tan, white-weathering, argillaceous limestone in medium beds with thin gray-brown shale partings. Phosphatic nodules are widely present in the lower foot in the northwestern outcrop area, where the Kings Lake Formation is missing.

**Glenhaven Member**—The Glenhaven Member of the Guttenberg Formation (Templeton and Willman, 1963, p. 113), the upper member, is named for Glenhaven, Grant County, Wisconsin, 2.5 miles northeast of the type section, in the same exposure as the type section for the Garnavillo Member, where the Glenhaven is 14.8 feet thick. The Glenhaven Member thins southward from the type area to 10-12 feet in north-

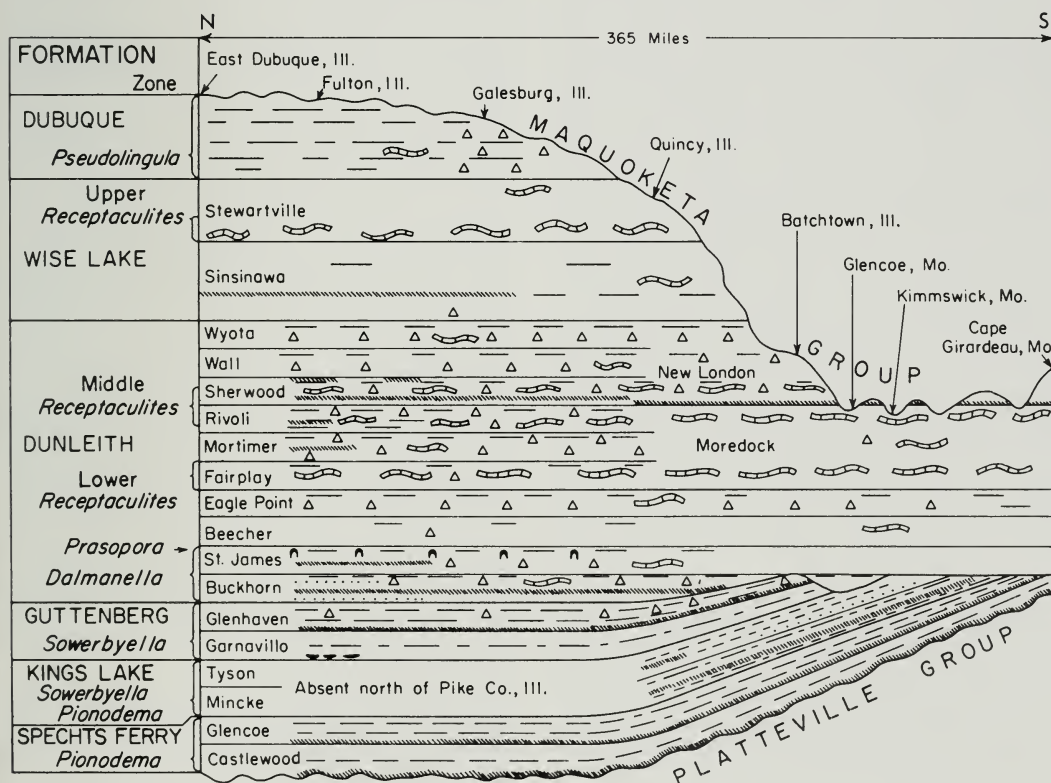


Fig. O-24—Diagrammatic cross section of the Galena Group showing the principal faunal zones and bentonite beds (after Templeton and Willman, 1963).

western Illinois and 7-9 feet in southwestern Illinois. In northwestern Illinois the Glenhaven is commonly separated from the overlying Dunleith Formation by a transition zone as much as a foot thick. The Glenhaven consists of tan, white-weathering, lithographic to very fine-grained limestone in beds 1-4 inches thick that are separated by layers of dark brown-red shale, generally thin but locally as much as 2 inches thick. The lower part is consistently more shaly, thinner bedded, and has wavier bedding planes than the upper part. The upper is purer and has more fossil debris and calcarenite layers. Lenses of chert are widely present in a single layer 1-2 feet above the base of the upper part and are scattered through the lower foot in the southwestern outcrops. In places in subsurface the entire formation is cherty. A bentonite bed up to 1 inch thick is widely present at the base of the Glenhaven in both northern and southern outcrop areas.

### *Kimmswick Subgroup*

The Kimmswick Subgroup (Ulrich, 1904, p. 111; Templeton and Willman, 1963, p. 114) consists of the dominantly pure limestone and dolomite formations that compose the middle part of the Galena Group. It excludes the shaly strata of the Dubuque Formation at the top and the shaly formations of the Decorah Subgroup at the base. It is named for Kimmswick, Jefferson County, Missouri, and the type section is in a quarry about a mile west of Kimmswick on the north side of Rock Creek just west of the mouth of Black Creek (approximately SE NE 18, 42N-6E). The Kimmswick Subgroup occurs throughout the area of the Galena Group. It is about 250 feet thick in northern Illinois, thins rapidly in an east-west belt through the central part of the state, and it is only 90-125 feet thick in most of the southern half of the state. It is dominantly limestone in the southern two-thirds of the state and dolomite north of there. It is subdivided into the basal Dunleith Formation, which contains some argillaceous beds and is medium bedded and generally cherty, and the Wise Lake Formation, which is pure, massive, and not cherty. Only the Dunleith Formation is present in the Kimmswick type locality because the Wise Lake is truncated by the Cincinnati Series south of the belt through the central part of the state where the Galena Group thins.

### *Dunleith Formation*

The Dunleith Formation (Templeton and Willman, 1963, p. 114), which overlies the Guttenberg Formation and underlies the Wise Lake Formation in the Galena Group, is named for Dunleith Township, Jo Daviess County. The type section is an exposure in the Mississippi River bluffs on the north side of East Dubuque (SE 19, 29N-2W), where the formation is 132 feet thick, including the unexposed lower 20 feet (fig. O-2B). The type section for the lowest strata (the St. James and Buckhorn Members) is at Buena Vista, Stephenson County. The

Dunleith Formation is exposed (fig. O-2C) in most of the area described in the discussion of the Galena Group. It is commonly 120-125 feet thick in the northern outcrop area and is 135 feet thick near New London, Missouri, where it is overlain by the Wise Lake Formation. South of New London, where the Wise Lake and upper Dunleith beds are missing, the formation is only about 100 feet thick. At East Dubuque the lower 27 feet is dolomite-mottled lithographic limestone and the upper 85 feet is dolomite. South and east of there, the limestone is progressively replaced by dolomite from the top down, and at Galena and farther east the formation is all dolomite, except for local areas such as north of Morris, Grundy County, in which it is dolomite-mottled limestone. In northwestern Illinois the Dunleith consists of alternating pure and argillaceous units. The pure units are medium to thick bedded and vuggy and the argillaceous units thin to medium bedded and dense. Chert nodules are common, particularly in the argillaceous units. The formation is subdivided into 10 conformable members, most of them consisting of a pure unit overlain by a thinner argillaceous unit. The Buckhorn (at the base) is overlain by the St. James, Beecher, Eagle Point, Fairplay, Mortimer, Rivoli, Sherwood, Wall, and Wyota Members. In Illinois the upper six members are recognized only in the northern dolomite and limestone facies. The argillaceous content decreases eastward and southward, and the member differentiation is less useful in the central northern outcrop area, although most of the members can be identified by such minor characteristics as abundance and types of chert, persistent thin bentonite beds, corrosion zones, fucoidal zones, and common fossils. In subsurface in northeastern Illinois the formation is even purer, contains little or no chert, and its members have not been differentiated (Buschbach, 1964). The southern limestone facies occurs throughout central and southern Illinois but is exposed only at Lowell, La Salle County, at Valmeyer, Monroe County, and near West Point Landing, Calhoun County. The lower four members are recognizable in the outcrops but rarely in subsurface. The overlying part of the Dunleith is divided into only two members, a lower massive calcarenite (Moredock Member) and an upper cherty, thin- to medium-bedded, calcarenitic limestone (New London Member). The Dunleith is sparsely fossiliferous in the dolomite facies, although *Paucicrura* [*Dalmanella*], *Prasopora*, and *Receptaculites* (fig. O-5) characterize certain zones. Bryozoans and crinoidal debris are particularly abundant in the southern limestone facies. The Dunleith Formation is called the "Drab" in the lead-zinc district, and it is equivalent to the upper part of the Decorah Shale and the lower part of the Prosser Limestone in the Mississippi Valley north of Illinois, to the Jessamine, Benson, and Brannon Members of the Lexington Limestone in Kentucky, to the upper part of the Hermitage and most of the Bigby-Cannon Formations in Tennessee, and to the Kirkfield Formation, the Sherman Fall Formation, and the Rust Member of the Coburg Formation in New York.

**Buckhorn Member**—The Buckhorn Member of the Dunleith Formation (Templeton and Willman, 1963, p. 119), the basal member, is named for Buckhorn Corners, Stephenson County, 2 miles east of the type section in a quarry at Buena Vista (NW SW NE 15, 28N-7E), where the member is 8.3 feet thick. It is commonly 5-8 feet thick but is generally absent in southwestern Illinois, where it is overlapped by the St. James Member. The Buckhorn consists of argillaceous, medi-

um to coarse, blue-gray dolomite heavily speckled with black, particularly at the top. It contains green shale partings and in the northwestern area is slightly sandy. It locally contains several very thin layers of bentonite. *Paucicrura* [*Dalmanella*] *rogata* is especially common. The Buckhorn is called the "Blue" in the lead-zinc district. With the overlying St. James Member, it is equivalent to the Ion Member at the top of the Decorah in the region northwest of Illinois.

**St. James Member**—The St. James Member of the Dunleith Formation (Templeton and Willman, 1963, p. 119), which overlies the Buckhorn Member, is named for St. James Cemetery in Stephenson County, 3 miles northwest of the type section, in the same exposure as the Buckhorn type section, where the St. James is 13.3 feet thick. It is called the "Gray" in the lead-zinc district. The St. James Member commonly is about 14 feet thick in the dolomite facies in northern Illinois and 8-12 feet thick in the southern limestone facies. In northern Illinois it is light tan, pure, medium-bedded, vuggy dolomite, but thin green shale partings are common in the upper 2-4 feet. It has black speckles but not as many as the Buckhorn. *Prasopora simulatrix* (fig. O-5) is common in the upper few inches in the extreme northwestern part of the state but has been found eastward only as far as Rockford, where it is rare. In the southern area the St. James is a coarse-grained, gray to brown, faintly gray-speckled calcarenite that locally has a few inches of conglomerate at the base.

**Beecher Member**—The Beecher Member of the Dunleith Formation (Templeton and Willman, 1963, p. 120) overlies the St. James Member and is named for Beecher Street in East Dubuque, Jo Daviess County, which is near the type section (part of the Dunleith type section), where the member is 6.3 feet thick. It commonly is about 8 feet thick in the northern outcrop area and 12 feet in the southern area. In the type section the Beecher is lithographic to fine-grained, dolomite-mottled limestone, typical of the northern limestone facies, but in most of northern Illinois it is relatively pure, noncherty, mainly massive, vuggy dolomite. High purity and massiveness differentiate it from the cherty Eagle Point Member above and the more argillaceous St. James below. In the southern limestone facies it is coarse-grained, gray to pink, almost wholly massive, pure calcarenite.

**Eagle Point Member**—The Eagle Point Member of the Dunleith Formation (Templeton and Willman, 1963, p. 120) overlies the Beecher Member and is named for Eagle Point, a prominent bluff on the west side of the Mississippi Valley in Dubuque County, Iowa, 2 miles north of the type section (part of the Dunleith type section), where the member is 11.8 feet thick. It is commonly 12-18 feet thick in the northern outcrop area and 9-10 feet in the southern area. It is characterized by well defined bands of chert nodules. It consists of slightly argillaceous dolomite-mottled limestone in the type section, but it is dolomite in most of northern Illinois. In the southern outcrop area it is calcarenite containing bands of chert, is finer grained, denser, and more argillaceous than the members above and below.

**Fairplay Member**—The Fairplay Member of the Dunleith Formation (Templeton and Willman, 1963, p. 121) overlies the Eagle Point Member, and is named for the town of Fairplay, Grant County, Wisconsin, 6 miles northeast of the type section (part of the Dunleith type section), where the member is 19.8 feet thick. It is commonly 14-20 feet thick. In the type section it consists of relatively pure, lithographic limestone and is the top of the northern limestone facies. It is largely free of chert, but scattered nodules appear locally. The upper 1-3 feet is persistently argillaceous or shaly. *Receptaculites oweni* is common in many beds, and the Fairplay is the Lower *Receptaculites* Zone. These characteristics extend into the northern dolomite facies, but the member is not differentiated in the southern limestone facies.

**Mortimer Member**—The Mortimer Member of the Dunleith Formation (Templeton and Willman, 1963, p. 121) overlies the Fairplay Member and is named for Mortimer Street in East Dubuque, Jo Daviess County, near the type section (part of the Dunleith type section) (fig. O-2B), where the member is 11.3 feet thick. It is commonly 10-13 feet thick. It consists of thick-bedded vuggy dolomite that contains bands of large white chert nodules. Its purity is between that of the pure Fairplay Member below and the argillaceous Rivoli above. It has a 2.2-foot argillaceous zone at the top in the type section, which thins to 5-6 inches in the Dixon and Rockford areas. It contains a few dense argillaceous beds. Thin lenses of bentonite occur along a prominent bedding plane at the top.

**Rivoli Member**—The Rivoli Member of the Dunleith Formation (Templeton and Willman, 1963, p. 122) overlies the Mortimer Member and is named for Rivoli Street in East Dubuque, Jo Daviess County, near the type section (part of the Dunleith type section) (fig. O-2B), where the member is 19 feet thick. The Rivoli Member thins eastward from the type section and is 13 feet thick in central northern Illinois. It is the most argillaceous of the Dunleith members. The upper 5 feet is a persistent argillaceous zone that is very cherty in the type section. The lower 5-6 feet contains bands of large chert nodules. Corrosion surfaces are strongly developed in the Rivoli. Thin lenses of bentonite are locally present at or near the top and probably occur at other horizons, especially along sharp reentrants. *Receptaculites oweni* is abundant in upper Rivoli strata and the overlying Sherwood Member—the Middle *Receptaculites* Zone.

**Sherwood Member**—The Sherwood Member of the Dunleith Formation (Templeton and Willman, 1963, p. 123) overlies the Rivoli Member and is named for Sherwood Street in East Dubuque, Jo Daviess County, near the type section (part of the Dunleith type section) (fig. O-2B), where the Sherwood is 13.6 feet thick. The Sherwood Member is 10 feet thick in central northern Illinois. It consists of relatively pure, vuggy dolomite with a strong argillaceous zone in the top 3.6 feet in the type section. Chert is erratic in occurrence, except for an almost continuous bed of chert just above the base in some areas. One of the most persistent bentonites, as much as 3 inches thick, occurs about 3 feet above the base, and another occurs locally at the base of the upper argillaceous zone.

**Wall Member**—The Wall Member of the Dunleith Formation (Templeton and Willman, 1963, p. 123) overlies the Sherwood Member and is named for Wall Street in East Dubuque, Jo Daviess County, near the type section (part of the Dunleith type section) (fig. O-2B), where the Wall is 9.7 feet thick. The Wall Member is commonly 10-12 feet thick. It is less argillaceous than the Sherwood below and more argillaceous than the Wyota above. The argillaceous zone at the top is not prominent, but the upper 1-3 feet commonly has more argillaceous mottling and thin, wavy shale partings than the beds below. A widespread bentonite bed as much as 4 inches thick occurs near the middle of the member. Chert nodules are common, and the beds above the bentonite are more cherty than those below.

**Wyota Member**—The Wyota Member of the Dunleith Formation (Templeton and Willman, 1963, p. 124), the uppermost member in northern Illinois, overlies the Wall Member, and is named for Wyota Street in East Dubuque, Jo Daviess County, near the type section (part of the Dunleith type section) (fig. O-2B), where the Wyota is 19.9 feet thick. The Wyota Member is commonly 18-20 feet thick. Most of it is purer than the Wall but less pure than the overlying Sinsinawa Member of the Wise Lake Formation. It is characterized by the persistence of thin beds with argillaceous flecks, particularly in the upper 10 feet, and by abundant chert nodules in well defined bands. The upper 2-4 feet is slightly ar-

gillaceous, locally shaly, and in many exposures makes a strong reentrant that marks the top of the Dunleith Formation.

**Moredock Member**—The Moredock Member of the Dunleith Formation (Templeton and Willman, 1963, p. 124) occurs in the southern limestone facies, overlying the Eagle Point Member. It is named for Moredock Lake, at Valmeyer, Monroe County, near the type section in the Mississippi River bluff (cen. N line SW 3, 3S-11W), where the member is 58.4 feet thick. The Moredock is commonly 60-70 feet thick where overlain by the New London Member, but in many exposures in the southern outcrop area the Moredock is overlain unconformably by Maquoketa Group strata, as it is at the type section, or by the Cape Limestone, and the upper few feet of the member are missing. The Moredock is exceptionally pure, coarse-grained calcarenite that is massive, cross-bedded, crinoidal, nearly white, and banded with pink, buff, and gray beds. Although the member is generally noncherty, large chert nodules or lenses of chert occur locally. It is distinguishable from the Eagle Point Member, which is finer grained, has bands of chert nodules, and is less pure.

**New London Member**—The New London Member of the Dunleith Formation (Templeton and Willman, 1963, p. 125) occurs in the southern limestone facies, overlying the Moredock Member and underlying the Wise Lake Formation. It is named for New London, Ralls County, Missouri, 2 miles south of the type section in a roadcut and in the bluff east of U.S. 61 on the north side of Salt River (NE SW 25, 56N-5W), where it is 32.8 feet thick. The top of the member is not exposed in the type section, but it occurs in a roadcut and bluff half a mile south of Frankford, Ralls County, on the north side of Peno Creek (SE NE and NE SE 2, 54N-4W). The New London consists of fine-grained to lithographic, calcarenitic, cherty limestone that contains beds of fine- to medium-grained calcarenite and some thin argillaceous and slightly shaly beds. Red-brown shale partings occur locally. It is finer grained than the Moredock below, coarser than the Wise Lake above, and less pure and thinner bedded than either. A persistent bentonite, as much as 2 inches thick, commonly marks the base of the member. It is believed to be equivalent to the bentonite near the base of the Sherwood Member in the northern area. The entire member is exposed only in the extreme northern part of the southern outcrop area, where it is 35-45 feet thick. South of there it is generally overlapped by Cincinnati strata, but the lower 3-5 feet, identified by the bentonite at its base, is present locally.

## Wise Lake Formation

The Wise Lake Formation (Templeton and Willman, 1963, p. 125) consists of relatively pure dolomite and limestone overlying the cherty Dunleith Formation and underlying the shaly Dubuque Formation. It is named for Wise Lake, a lake on the Mississippi River floodplain near the type section at the north end of a prominent bluff, 6 miles south of Galena, Jo Daviess County (cen. NE 21, 27N-1E), where the formation is 70.9 feet thick. The Wise Lake Formation, persistently 67-75 feet thick, occurs throughout the northern outcrop area (fig. O-2B, C) and southward in subsurface to the central part of the state, where it is sharply truncated by Cincinnati strata. The Wise Lake consists of noncherty, medium- to thick-bedded, vuggy, pure dolomite in the northern outcrop area. The southern limestone facies is not exposed in Illinois, but in outcrops near New London, in Ralls County, Missouri, it is thick-bedded, fine-grained, to lithographic, pure limestone. The Wise Lake is subdivided into two members; the basal Sinsinawa Member is thinner bedded and slightly less pure than the Stewartville above it. Re-

ceptaculites oweni (fig. O-5) is abundant and persistently present in the lower 10-15 feet of the Stewartville, called the Upper *Receptaculites* Zone, and is associated with a gastropod-cephalopod fauna. *Maclurites cuneata* and *Hormatoma major* (fig. O-5) are common in some localities. The Sinsinawa Member is less fossiliferous but contains gastropods and, in places, a few *Receptaculites*. The Wise Lake Formation is the purest of the carbonate formations in the Galena Group and is equivalent and lithologically similar to relatively pure formations throughout much of the continent. The Wise Lake is thought to represent the greatest submergence of the continent during Paleozoic time. The Wise Lake Formation consists of strata formerly included in the Stewartville Formation and in the upper part of the Prosser Formation in the Upper Mississippi Valley. It is equivalent to the Steuben Member of the Cobourg Limestone in New York and Ontario, the upper part of the Lexington Limestone in Kentucky, and the upper part of the Bigby-Cannon Formation in Tennessee.

**Sinsinawa Member**—The Sinsinawa Member of the Wise Lake Formation (Templeton and Willman, 1963, p. 126), the lower member, is named for the Sinsinawa River in Jo Daviess County, along which it is well exposed. The type section is a roadcut along U.S. Highway 20 on the east side of the Galena River at Galena (SW SE NE 20, 28N-1E), where it is 33 feet thick, although a few feet at the top (exposed in the Wise Lake type section) is missing. The Sinsinawa Member is 35-40 feet thick. Where exposed in the northern outcrop area (fig. O-2B), most of it is medium- to thick-bedded, pure, vuggy dolomite, but it contains a few dense, slightly argillaceous beds. A 1-2 inch bed of bentonite is widely present about 17 feet above the base, and a thin bentonite occurs locally about 7 feet higher. The Sinsinawa Member is equivalent to the upper, noncherty part of the Prosser Limestone of Minnesota.

**Stewartville Member**—The Stewartville Member of the Wise Lake Formation (Ulrich, 1911, pl. 27), the upper member (originally the Stewartville Formation), is named for Stewartville, Olmstead County, Minnesota, which is half a mile east of the type section, a quarry on the north side of the Root River, where 28 feet of dolomite in the lower part of the member is exposed (Kay, 1935a, p. 567). The Stewartville Member is about 60 feet thick in the type locality, but only 30-35 feet thick in northern Illinois. It is largely thick-bedded, pure dolomite, and many samples from the lower 10-15 feet (the Upper *Receptaculites* Zone) contain almost no insoluble residue. The bedding becomes thinner upward as a gradual transition to the shaly Dubuque Formation above takes place. The top of the Stewartville is placed at the lowest definitely argillaceous or shaly bedding plane. Above this position is the first occurrence of *Pseudolingula iowensis*, which is common in the higher, more shaly part of the Dubuque Formation. The Stewartville Member is the *Maclurea* bed of early reports.

## Dubuque Formation

The Dubuque Formation (Sardeson, 1907, p. 193) is the shaly dolomite at the top of the Galena Group. It is named for Dubuque, Dubuque County, Iowa, and the type section is a quarry in Dubuque, east of Columbia College at the top of the West 14th Street hill, where 33 feet of Dubuque, its top eroded, is exposed. In Illinois the Dubuque Formation occurs only in the northwestern part of the state, where it is 40-45 feet thick (Templeton and Willman, 1963, p. 128). It is truncated by Maquoke-



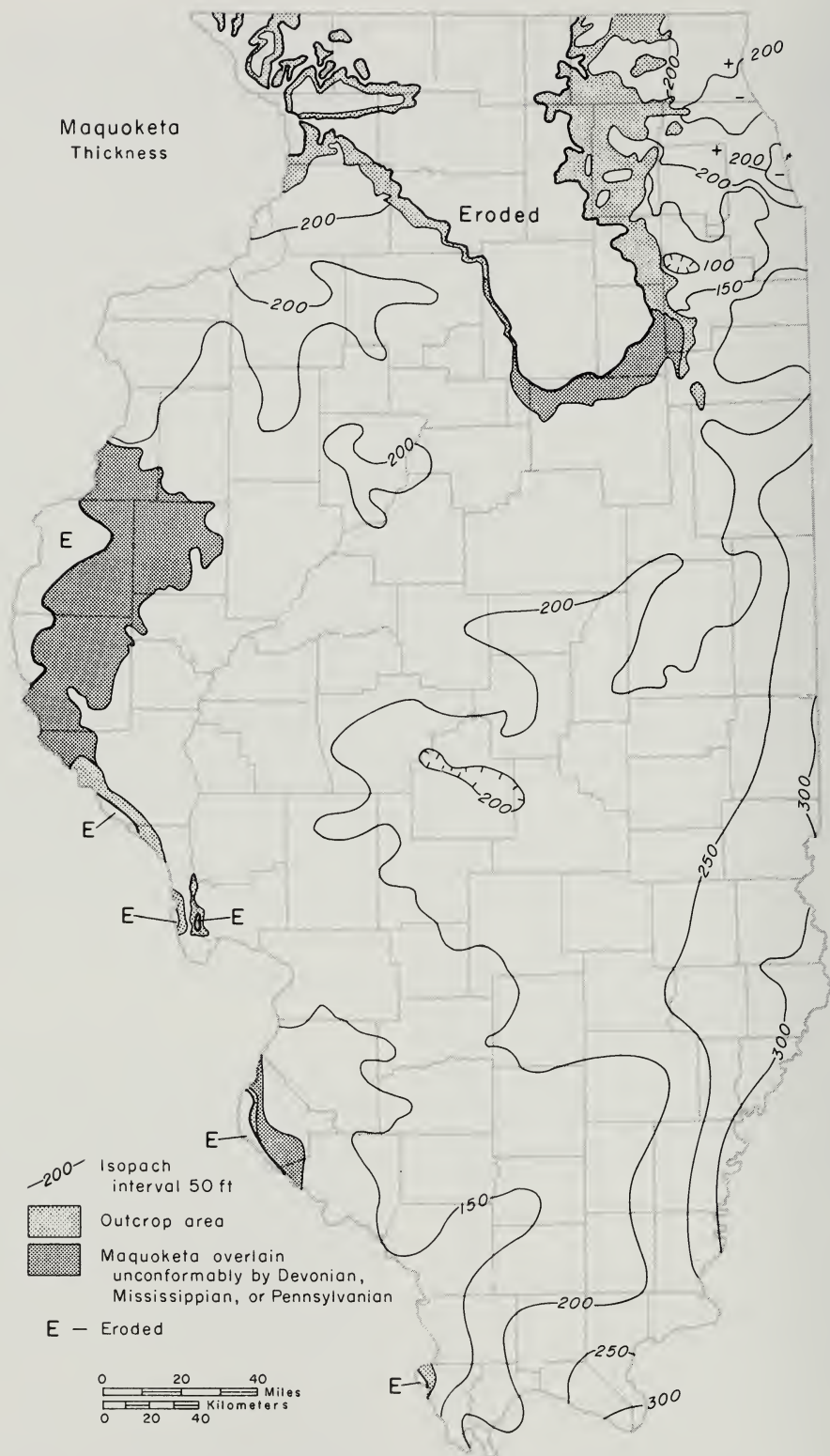


Fig. O-26—Thickness of the Maquoketa Group.

with the entire series and are subdivided into the Edenian (earliest), Maysvillian, and Richmondian Stages (Templeton and Willman, 1963). The fauna of the Cincinnati strata in Illinois has not been studied in sufficient detail to determine the precise position of the stage boundaries.

Despite unconformities at the top and bottom, it appears that almost the entire Cincinnati Series is represented in Illinois. The

Cape Limestone at the base of the Cincinnati in southern Illinois is as old or older than the oldest Cincinnati strata at Cincinnati. The Fort Atkinson Limestone, in the middle of the Maquoketa Shale Group, has a fauna that closely matches that of the Richmondian Waynesville Limestone of the type region (Savage, 1925a). The *Cornulites* Zone, which occurs near the top of the Richmondian, is present in the upper part of the Brainard Shale

ILLINOIS IN GENERAL

Meek and Warthen 1865	White 1870	Colvin 1906 Lodd 1929	DuBois 1945	Koy 1954	Gutstadt 1958b	Present, Templeton and Willmon 1963
	Iowa	Iowa			Nw. Ill.	
		Fm. Member	Fm.	St. Fm. Member	Fm. Gr. Formation	St. Gr. Formation
Cincinnati Group	Maquoketa Shales	CINCINNATIAN (RICHMOND) Maquoketa	Upper	RICHMONDIAN Maquoketa	Orchard Creek	RICHMONDIAN Maquoketa
		CINCINNATIAN (RICHMOND) Maquoketa	Middle	RICHMONDIAN Maquoketa	Cope	RICHMONDIAN Maquoketa
		CINCINNATIAN (RICHMOND) Maquoketa	Lower	RICHMONDIAN Maquoketa	Eden	EDENIAN MA Maquoketa
			Fernvale			

EXTREME SOUTHWESTERN ILLINOIS

Werthen 1866	Savage 1908	Savage 1910b	Savage 1916	Gutstadt 1958	Templeton and Willmon, 1963	Present, Willmon et al. 1967
Gr. Formation	Formation	Formation	Formation	Gr. Formation	Gr. Formation	Gr. Formation
Cape Girardeau	SILURIAN	SILURIAN		SILURIAN	SILURIAN	Girardeau
shale	shale	Orchard Creek	SILURIAN	Maquoketa	Maquoketa Scales	Maquoketa Scales
Thebes	Thebes	Thebes	Thebes			
shale						
		Fernvale	Fernvale			
				Cape	Cape	Cape

St.- Stage, Fm.- Formation, MA - MAYSVILLIAN, Gr.- Group, Mbr.- Member

Fig. O-27—Development of the classification of the Cincinnati Series.

in Illinois. The Neda Formation and the Girardeau Limestone at the top may be younger than the youngest strata in the type Cincinnati.

The unconformity at the base of Cincinnati strata is marked by the sharp truncation of the upper half of the Trentonian Galena Group limestone and dolomite by the Cincinnati strata in an east-west belt across central Illinois. The Dubuque and Wise Lake Formations and the upper part of the Dunleith Formation were eroded in this belt and are not known south of there, although they may be present in subsurface in the southeastern part of the state where the Galena Group thickens. The Lower Depauperate Zone at the base of the Maquoketa Group is continuous across the truncated formations. Impact of a large meteorite near Glasford in western Illinois probably accounts for the intensive deformation of the Champlainian and older strata before deposition of the Maquoketa Group in that area (Buschbach and Ryan, 1963).

### Edenian Stage

The Edenian Stage of the Cincinnati Series (Newberry, 1873, table opp. p. 89; Twenhofel et al., 1954, chart), the basal stage, is based on the Eden Group, named for Eden Park in Cincinnati, Ohio. In Illinois it includes the Cape Limestone and the lower part of the Scales Shale (essentially the part underlying the Upper Depauperate Zone), which consists of the Thebes Sandstone Member and probably the Orchard Creek Shale Member in extreme southern Illinois and the middle and lower parts of the Elgin Shale Member elsewhere. The presence of dark brown to nearly black shale is characteristic of the Elgin Shale Member and lower Edenian strata in the type region of the Cincinnati.

### Maysvillian Stage

The Maysvillian Stage of the Cincinnati Series (Foerste, 1905, p. 150; Twenhofel et al., 1954, chart), which overlies the Edenian Stage, is named for Maysville, Kentucky. In Illinois it consists of strata in the upper part of the Scales Formation, including the Upper Depauperate Zone and the overlying argillaceous limestone beds that contain *Isotelus* in abundance. The Girardeau Limestone in the extreme southwestern part of Illinois is approximately at this position, but its relation to the Upper Depauperate Zone is not known. Its fauna has long been considered to be more closely related to Silurian than to Ordovician

faunas (Savage, 1917), and it therefore probably is late Richmondian in age.

### Richmondian Stage

The Richmondian Stage of the Cincinnati Series (Winchell and Ulrich, 1897, p. ciii; Twenhofel et al., 1954, chart), the uppermost stage, is named for Richmond, Indiana. In Illinois it includes the uppermost part of the Scales Shale, the Fort Atkinson Limestone, the Brainard Shale, the Neda Formation, and the Girardeau Limestone. The red shales of the Neda suggest correlation with red shales and sandstones in the Queenston and Juniata Formations at the top of the Cincinnati Series in the Appalachian region.

### Cape Limestone

The Cape Limestone (Templeton and Willman, in Gutstadt, 1958b, p. 524), the oldest Cincinnati formation, is named for Cape Girardeau, Missouri, and the type section is an exposure on Main Street just north of Broadway in Cape Girardeau, where the formation is 8.5 feet thick, the maximum thickness observed (Templeton and Willman, 1963, p. 134). The Cape Limestone has a patchy distribution in the outcrop area in Missouri from St. Louis to Cape Girardeau. It occurs in the southwestern part of Illinois, where Cincinnati strata deeply truncate the Trentonian Series, but it is exposed only at Valmeyer, Monroe County (SW 3, 3S-11W), where it is 1.5 feet thick. A few small outcrops formerly occurred near Thebes in Alexander County but are now covered. The Cape Limestone occurs mainly in shallow channels eroded in the top of the Dunleith Formation. In the northern part of the area, it is overlain by the Elgin Shale Member of the Scales Shale, as shown by the presence of the Lower Depauperate Zone above it at Valmeyer. In the southern part of the outcrop area, it is overlain by the Thebes Sandstone Member of the Scales. The Cape Limestone is a light gray to reddish gray, coarse-grained, fossiliferous calcarenite. It occurs in medium to thick beds with weak shaly partings. It has a large fauna characterized by brachiopods, particularly *Lepidocyclus capax*, and crinoids. The Cape Limestone was for many years called the Fernvale Limestone. It is correlated with the Fernvale Limestone in Arkansas and Oklahoma but not with the type Fernvale in Tennessee, which, being Richmondian in age, is much younger.

### Maquoketa Shale Group

The Maquoketa Shale Group (White, 1870, p. 180-182) is named for exposures on the Little Maquoketa River in Dubuque County, Iowa. It underlies most of Illinois (fig. O-26), unconformably overlying the Galena Group and truncating the upper half of the Galena in the southern part of the state, except for the southwestern area where it rests conformably

on the Cape Limestone. It is unconformably overlain by Silurian strata, which locally truncate the upper half of the Maquoketa, except in the southwestern area where it is overlain conformably by the Girardeau Limestone. In western Illinois the sub-Kaskaskia unconformity at the base of the Middle Devonian rocks cuts through the Silurian strata and into the Maquoketa, and farther west near the Mississippi River it completely truncates the Maquoketa (fig. O-26). The sub-Absaroka unconformity at the base of the Pennsylvanian rocks locally cuts through the Maquoketa along the La Salle Anticline (fig. P-4). Except where thinned by the unconformities, the Maquoketa is 180 to nearly 350 feet thick.

Throughout most of Illinois the Maquoketa Shale Group (fig. O-25) consists of a lower unit, dominantly shale (the Scales Shale), overlain by a middle limestone (the Fort Atkinson Limestone), and an upper shale (the Brainard Shale) (DuBois, 1945; Gutstadt, 1958b; Templeton and Willman, 1963; Buschbach, 1964). In northern Illinois, the Neda Formation (red shale and hematitic oolite) is locally present at the top of the group. In extreme southwestern Illinois, the Maquoketa Group includes only the Scales Shale. Some of the complex facies variations within the Maquoketa Group in Illinois have been shown by DuBois (1945, fig. 3), but his middle zone is not equivalent in all areas to the Fort Atkinson Limestone, which is now restricted to the section in which limestone or dolomite is dominant.

The Maquoketa Shale contains two zones with distinctive pyritic and phosphatic beds, called depauperate zones because they contain only small fossils, largely a coquina of mollusks. The Lower Depauperate Zone, at the base of the Scales Shale, is widely present throughout the state, but the Upper Depauperate Zone, near the top of the Scales, has been found only locally in central and northeastern Illinois. The limestone beds and the calcareous shale beds in the Maquoketa Group generally contain a large and varied fauna (fig. O-5). Large brachiopods are common, and branching bryozoans are especially abundant. In a zone near the top in northwestern Illinois, specimens of *Phragmopora* that reach 4 inches in diameter are locally abundant. Some beds of calcarenite consist largely of bryozoan and crinoidal debris.

Various group and formation names have been used in differentiating the type Cincinnati (Weiss and Norman, 1960). In southeastern Indiana, part of the type region, the Cincinnati strata are assigned to the Ma-

quoketa Group (Gray, 1972). The Maquoketa Group is equivalent to Collingwood and Queenston strata in Ontario and New York, to the Sylvan Shale to the southwest, and to the Reedsville Shale and the Sequatchie Formation to the south and southeast of Illinois.

## Scales Shale

The Scales Shale (Templeton and Willman, 1963, p. 135, in which it was called the Scales Formation), the "lower shale" formation in the Maquoketa Group in most of Illinois, is named for Scales Mound, Jo Daviess County, and the type section is a railroad cut on the west side of the town (SW NE SW 26, 29N-2E). Only the lower 30 feet, overlying the Dubuque Formation, is exposed in the type section, but the upper 18 feet is exposed 5 miles east in another railroad cut (SW SW SW 15, 29N-3E). The Scales Shale is extensive but is exposed only in northwestern Illinois and in small areas near West Point Landing in Calhoun County, Valmeyer in Monroe County, and Thebes in Alexander County. The formation is generally 75-100 feet thick, but it ranges from 50-150 feet thick. The lower part is generally dark gray to dark brown shale, which is differentiated as the Elgin Shale Member. At the top of the Scales is a gray shale—the Clermont Shale Member—that contains beds of argillaceous limestone. In the southwestern part of Illinois, brown sandstone and siltstone at the base of the Scales is differentiated as the Thebes Sandstone Member, and the shale overlying it is the Orchard Creek Shale Member. The Scales Shale has been called "the lower brown shale member" (Willman and Payne, 1942), "the lower shale zone" (DuBois, 1945), or the Scales Formation (Templeton and Willman, 1963).

**Elgin Shale Member**—The Elgin Shale Member of the Scales Shale (Calvin, 1906, p. 60, 98) is named for Elgin, Fayette County, Iowa. It forms the major part of the formation and is partly exposed in many localities in northwestern Illinois and locally in the other outcrop areas of the Maquoketa Group. Although dominantly shale, and in some areas almost entirely shale, the member contains beds of dolomite, limestone, siltstone, and sandstone. The lower two-thirds of the shale is commonly dark gray or dark brown, and locally in eastern Illinois it is nearly black. The shale generally becomes lighter in color to the northwest, and in the Scales type section only a few beds are dark. The Lower Depauperate Zone consists of one or several thin depauperate beds at the base or in the lower few feet of the Elgin Shale. At Valmeyer, Monroe County, depauperate beds occur at the base of the shale and as much as 9 feet above the base. A similar depauperate bed, the Upper Depauperate Zone, occurs in the upper part of the Elgin Shale Member. It was formerly exposed in the Goose Lake clay pit in Grundy County but is now covered. At Goose Lake it is 60 feet above the base of the Scales Shale, is 20 feet below the top, and is overlain by shale and argillaceous limestone containing *Isotelus*, which forms the top of the member. The Upper Depauperate Zone has been encountered in borings only in central and northeastern Illinois.

**Clermont Shale Member**—The Clermont Shale Member of the Scales Shale (Calvin, 1906, p. 60, 98), the upper member, is named for Clermont, Fayette County, Iowa. It is dominantly gray shale overlying the zone of interbedded shale and limestone in the upper part of the Elgin Shale Member. Where that zone cannot be distinguished, which is commonly the case in subsurface, it is not differentiated. It is generally

15-20 feet thick but thickens in central and southeastern Illinois.

**Thebes Sandstone Member**—The Thebes Sandstone Member of the Scales Shale (Worthen, 1866, p. 139; Savage, 1909, p. 515) is named for Thebes, Alexander County, and the type section consists of exposures in the Mississippi River bluffs in Thebes (SW SE 8, 15S-3W). The Thebes Sandstone Member is exposed in Illinois only in the vicinity of Gale and Thebes, and it occurs in subsurface only in the extreme southwestern part of the state. It overlies the Cape Limestone and grades or intertongues eastward and northward into the lower part of the Elgin Shale Member. It is overlain by the Orchard Creek Shale Member, which probably is also laterally equivalent to part of the Elgin Shale Member. About 65 feet of the Thebes Sandstone Member is exposed in the bluff north of Thebes (SE 5, 15S-3W), but it has a maximum thickness of about 160 feet. The Thebes consists of dark brown, silty, fine-grained sandstone, largely medium to thick bedded and locally cross bedded. In places it is largely brown siltstone, but it locally contains beds of gray to brown shale several feet thick. Several types of fucoid marks are common in the upper 35 feet.

**Orchard Creek Shale Member**—The Orchard Creek Shale Member of the Scales Shale (Savage, 1909, p. 515) is named for a small exposure along Orchard Creek, 2 miles south of Thebes, Alexander County. This section is now covered, but the Orchard Creek is exposed in the Mississippi River bluffs a mile north of Thebes (SE 5, 15S-3W), where it is 27 feet thick, overlies the Thebes Sandstone Member, and is overlain by the Girardeau Limestone. The Orchard Creek Shale Member is exposed locally in and near the Mississippi bluffs in Alexander County from Gale southward almost to Fayville. It is 10-30 feet thick in the outcrop area. It is largely blue-gray shale, but in the thickest exposures the upper part is interbedded with fine-grained limestone. The Orchard Creek is probably a lateral equivalent of part of the Elgin Shale Member, but its precise position is uncertain, and it could be equivalent even to the Brainard Shale. It is differentiated only where it overlies the Thebes Sandstone Member. The Orchard Creek contains a large fauna (Savage, 1917). It was long assigned to the Silurian System, but the presence of *Climacograptus putillus* indicates Cincinnati age (Pryor and Ross, 1962).

## Fort Atkinson Limestone

The Fort Atkinson Limestone (Calvin, 1906, p. 60, 98), the "middle limestone" formation in the Maquoketa Group, is named for exposures at Fort Atkinson, Winnebago County, Iowa. It is exposed in northeastern Illinois, particularly at Wilmington, Will County (SE SW NW 25, 33N-9E) and near the Dresden Island Dam, Grundy County (SE NE NW 34, 34N-8E). The Fort Atkinson Limestone has been called the Divine Limestone (Lamar and Willman, 1931) and the "middle limestone" (DuBois, 1945). It is widely distributed in subsurface in Illinois and is commonly 15-40 feet thick. However, in some areas, for instance in much of the Maquoketa outcrop area in northwestern Illinois, it becomes very shaly and is inseparable from the shales above and below. In other areas it includes limestone laterally equivalent to the shale formations above and/or below. The Fort Atkinson changes within short distances from white or pink, coarse-grained, crinoidal limestone to brown fine-grained dolomite or gray argillaceous limestone. In some localities the upper part is limestone, the lower part dolomite. The amount of interbedded shale varies greatly. The Fort Atkinson is generally fossiliferous with a large fauna of

brachiopods and bryozoans (Savage, 1925a). It correlates with the Waynesville Limestone in Ohio and Kentucky.

## Brainard Shale

The Brainard Shale (Calvin, 1906, p. 60, 97), the "upper shale" formation in the Maquoketa Group, is named for an exposure near Brainard, Fayette County, Iowa. It occurs throughout the area of the Maquoketa Group, except in local areas where it is truncated by the sub-Silurian unconformity. Although widely present near the surface in the mounds and ridges in northwestern Illinois, it is generally covered by slumped material from the overlying Silurian dolomite formations, and actual outcrops are small and scarce. It is exposed locally in northeastern Illinois, particularly near Channahon and Ritchey in Will County, near Elgin in Kane County, and in small areas in Calhoun and Jersey Counties. The Brainard Shale is 75-100 feet thick where it is not deeply truncated by the sub-Silurian unconformity. In the outcrops it consists of greenish gray to green shale, partly dolomitic, and locally silty. In subsurface it contains beds of siltstone, and locally limestone or dolomite. It is generally much lighter colored and softer than the Scales Shale. Two thin bentonite beds locally occur near the top in southeastern Illinois. The Brainard is commonly fossiliferous, and the presence of *Cornulites* in the upper part suggests equivalence to the Elkhorn Formation at the top of the Richmondian strata in Indiana and Ohio.

## Neda Formation

The Neda Formation (Savage and Ross, 1916, p. 193, in which it was called Neda iron ore), the youngest formation in the Maquoketa Group in northern Illinois, is named for exposures near Neda, Dodge County, Wisconsin. The Neda Formation occurs in local areas in northern Illinois and is exposed along the Kankakee River south-east of Ritchey, Will County (26, 27, 35, 36, 32N-10E, particularly in NE NW SW 36). In that area it is 4-8 feet thick, overlies the green Brainard Shale, and is overlain by the Kankakee Formation or, locally, by 1-2 feet of the Wilhelmi Formation of Silurian age. The Neda is generally less than 10 feet thick in Illinois. It is largely red shale interbedded with red-brown or black oolite consisting of flattened spheroids of goethite or hematite that average about 0.5 mm across. In places it contains a few beds of gray or green shale. Although it rests sharply on the underlying Brainard Shale, there is no evidence of an unconformity. The upper contact, however, is sharp and erosional. The basal Silurian rocks in places contain streaks of reddish shale and black oolites that were probably reworked from the Neda. The Neda occurs only in areas where the Brainard Shale is relatively thick and where the basal Silurian formations, the Wilhelmi and Elwood Formations, which generally occur in channels eroded in the top of the Brainard, are absent or very thin. The major unconformity, therefore, is on top of the Neda Formation, which favors its assignment to the Maquoketa Group (Workman, 1950; Buschbach, 1964) rather than to the basal Silurian Noix Oolite Member (Athy, 1928). The Neda is not fossiliferous in Illinois, but Savage and Ross (1916) reported a Cincinnati fauna in the Neda in its type region. The Neda is believed to be a thin western tongue of the Queenston delta of the Appalachian region.

## *Girardeau Limestone*

The Girardeau Limestone was originally named the Cape Girardeau Limestone (Swallow, 1855, p. 109) for outcrops at Cape Point, 1.5 miles northeast of Cape Girardeau, Missouri (SW NE SE 28, 31N-14E), but the shorter form "Girardeau" has been used since the late 1800s (Savage, 1909). In Illinois it occurs only in the extreme southwestern part, and it is exposed only near Thebes, Alexander County. About 30 feet is exposed along Orchard Creek south of Thebes (SW SE NW 21, 15S-3W), which is about its maximum thickness, although the base is not exposed. The base appears to be conformable on the Orchard Creek Shale, the upper part of which contains a few limestone beds like the Girardeau. The top is a prominent unconformity that northward from Thebes completely truncates the Girardeau before

reaching Gale. The Girardeau Limestone consists of unevenly bedded, fine-grained to lithographic, dark brown limestone. It has shaly partings and silicified silty interbeds that commonly contain black chert nodules. The Girardeau contains a large fauna, most of it preserved on the bedding planes (Savage, 1917). Although Savage considered the fauna had affinities closer to the Silurian than the Ordovician, the strong unconformity at the top and the transitional, local character of the fauna have caused many to favor its classification as Ordovician, a practice followed in Illinois since 1967 but still considered tentative. The relation of the Girardeau to the Maquoketa elsewhere in Illinois is not known. Judged on the basis of thickness of the underlying Maquoketa strata, it could be approximately equivalent to the Fort Atkinson Limestone, but it does not resemble it. It could be as young or younger than the Neda Formation, the interpretation at present favored.

## *SILURIAN SYSTEM*

*H. B. Willman and Elwood Atherton*

The Silurian System (Murchison, 1835, p. 48-49; Lapworth, 1879, p. 12-14), named for the Silures, a tribe of people who lived in the type area in Wales during Roman times, underlies most of Illinois and is the surface of the bedrock in four areas (fig. S-1). Silurian strata are well exposed in all four areas (fig. S-2). In northeastern Illinois, Silurian rocks are exposed in large, deep quarries in the Chicago region and in the bluffs of the Des Plaines, Kankakee, Du Page, and Fox Valleys, but in the northern half of that area they are deeply buried by glacial drift. In northwestern Illinois, the Silurian strata are the resistant rocks that cap nearly all the mounds, and they are well exposed in the Mississippi River bluffs from the Galena area southward to the Rock Island vicinity and also along tributary valleys for several miles east of the bluffs. In western Illinois, the Silurian System has been uplifted along the Lincoln Anticline and the Cap au Grès Faulted Flexure and is well exposed in the Mississippi and Illinois River bluffs in Jersey and Calhoun Counties. In southern Illinois, the exposures are limited to the Mississippi bluffs and tributary valleys in Alexander County and southern Union County. The Silurian rocks in all these areas

were long called Niagara Limestone (Worthen, 1866; Bannister, 1868; Shaw, 1873).

The Silurian System has a maximum thickness of nearly 1000 feet in and below some pinnacle reefs in the area east of East St. Louis. However, the system is more commonly 400-600 feet thick in that area and farther north (fig. S-1). South of the pinnacle reefs the Silurian rocks are generally only 300-400 feet thick.

The Silurian System is subdivided into three series—the Alexandrian Series (below), which is based on exposures in Alexander County, Illinois, and the Niagaran and Cayugan Series, both based on exposures in the Niagara Falls area in New York and Ontario. Because of pronounced changes in lithology, different rock-stratigraphic classifications have developed in the widely separated outcrop areas in Illinois, and 15 formations and 10 members are now recognized (figs. S-3 to S-10). The subsurface correlations between the outcrop areas have not been firmly established for some units.

The Silurian rocks are dominantly carbonates—almost entirely dolomite in the northern part of the state (Willman, 1943, 1973) but

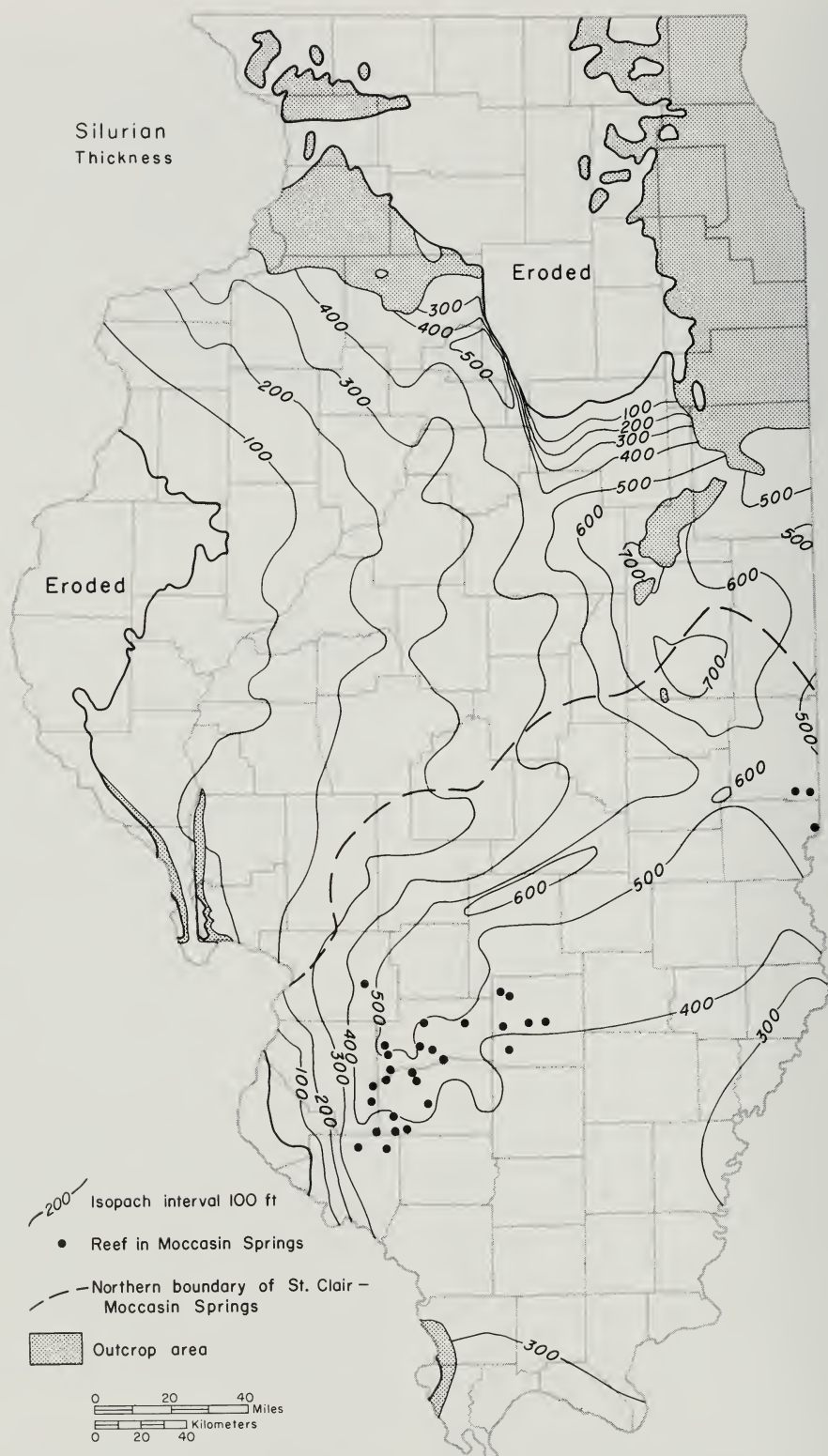


Fig. S-1—Silurian System thickness, outcrop areas, nomenclature boundary, and reefs in the Moccasin Springs Formation.

largely limestone, siltstone, and shale in the southern part (Lowenstam and DuBois, 1946; Lowenstam, 1949). With the overlying Devonian carbonate rocks, they form the Hunton Limestone Megagroup.

The Alexandrian formations, the lower Niagaran rocks, and all of the Silurian rocks south of the reefs maintain distinctive characteristics and lateral continuity for long distances (fig. S-11), but where reefs are present the sediments have abrupt lateral variations in lithology, and few units can be widely traced. The reefs are very pure carbonate. The northern reefs, in the Racine Formation, are mainly dolomite, but the southern reefs, in the Moccasin Springs Formation, are largely limestone. The interreef rocks are less pure, varying from cherty silty dolomite to argillaceous dolomite around the Racine reefs and from argillaceous limestone to calcareous shale and siltstone around the Moccasin Springs reefs. However, in northwestern Illinois the interreef rocks, except in local areas, are nearly pure dolomite and are similar in lithology to the reef rock.

Illinois was almost continuously beneath the sea during Silurian time. The most striking features in the Silurian sea were the reefs that formed in Niagaran time in a broad area reaching from the Ozark region northeastward across Illinois, Indiana, and Ohio to Ontario (Lowenstam, 1949, 1957). Another group of reefs in northwestern Illinois, Iowa, northeastern Illinois, and eastern Wisconsin may have been part of an archipelago bordering the Wisconsin Arch. The two belts of reefs essentially meet in the Kankakee Arch area and form part of a barrier around the Michigan Basin.

In the relatively deep water south of the reef front and around the southernmost reefs, the sediments that were deposited during the growth of the reefs are largely red, green, gray, impure, noncherty limestone, siltstone, and shale; farther north, the reefs are surrounded by gray, cherty, silty dolomite. The red sediments are more dominant to the southwest and probably were derived from that direction.

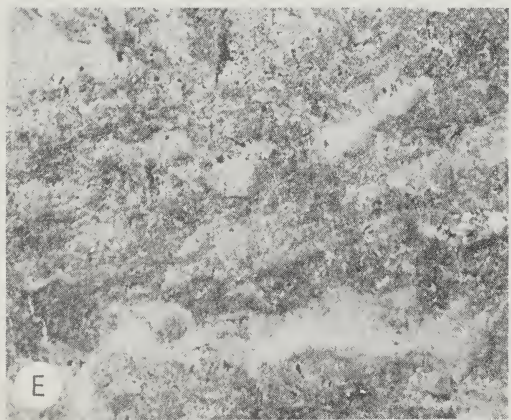
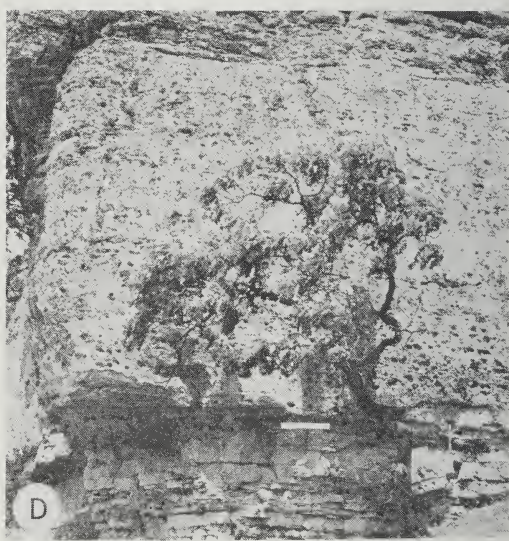
In the southern reef area, the oldest reefs probably began to grow during deposition of the upper part of the St. Clair Formation, as indicated by the presence of local lenses of pure sediments, probably wash from reefs. However, the major reefs began to grow a little later, at or just above the base of the Moccasin Springs Formation. In the northern areas, major reef growth began at approxi-

mately the same time as in the south, the beginning of Racine deposition. The great thickness of the southern reefs appears to be related to the progressive sinking of the deep part of the Illinois Basin, the Fairfield Basin (fig. 12).

The reefs continued as prominent features through Silurian time, although the presence of Niagaran fossils in the upper parts of some reefs suggests that reef growth did not extend into Cayugan time. However, as all of the reefs are overlain unconformably by Middle Devonian or younger sediments, the Cayugan, and perhaps even the early Devonian, parts of the reefs could have been present and eroded. In either case, the sea continued to occupy the Illinois Basin around and south of the reefs into Devonian time, and several hundred feet of Lower Devonian sediments were deposited in the basin and largely filled it.

In the classification based on major unconformities, the Silurian rocks belong to the Tippecanoe Sequence (fig. 14). They are separated from the underlying Ordovician rocks by an unconformity, as previously described. In the part of the Illinois Basin south of the reefs, deposition appears to have been essentially continuous from Silurian to Devonian time, but the sub-Kaskaskia unconformity at the base of the Middle Devonian rocks truncates the reefs and the Niagaran, Lower Devonian, and Cayugan rocks on the flanks of the reefs. Cayugan and Lower Devonian sediments may not have been deposited north of the area of the Moccasin Springs Formation (fig. S-1), but if they were present they must have been eroded, because the unconformity cuts deeply into Niagaran strata in that area. Well rounded, medium-grained quartz sand found locally in upper Silurian rocks in subsurface is largely Middle Devonian sand introduced along joints (Summerson and Swann, 1970). In extreme western Illinois, the Silurian strata were entirely eroded before the Middle Devonian limestone was deposited. No major unconformities are recognized within the Silurian System, although sharp contacts and channeling between the Kankakee and Edgewood Formations in western Illinois and the Sexton Creek and Edgewood Formations in southern Illinois may indicate movements on local structures on the flank of the Ozarks. The Alexandrian and Niagaran rocks are separated by a widespread, smooth surface that probably indicates a diastem.

Fossils are generally abundant in the relatively pure carbonate rocks of the Silurian System (fig. S-12) but are scarce in the more



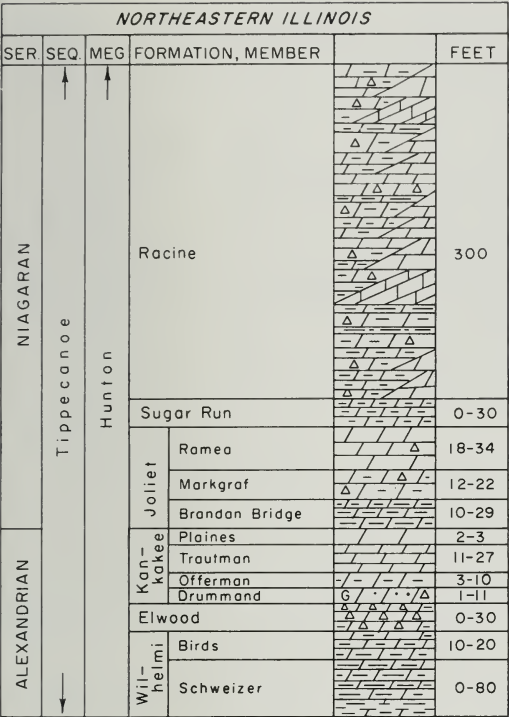


Fig. S-3—Columnar section of the Silurian System in northeastern Illinois.

argillaceous and silty strata. Five faunal zones are extensive. (1) The *Platymarella* Zone at the base of the Kankakee Formation is essentially equivalent to the *Virginia* Zone found to the north in Wisconsin, Michigan, and Ontario. The two fossils are closely related pentamerids. (2) The *Microcardinalia* Zone at the top of the Kankakee Formation and in the upper part of the Sweeney Formation is widely present at the top of Alexandrian rocks. (3) A zone of abundant arenaceous Foraminifera, characterized by Ammodiscidae, occurs at the base of Niagaran strata, although it has not been found in northwestern Illinois. (4) The *Pentamerus* Zone, which in Illinois occurs only in the northwestern part of the state, is regionally present at or near the base of the Niagaran Series. (5) The uppermost Niagaran

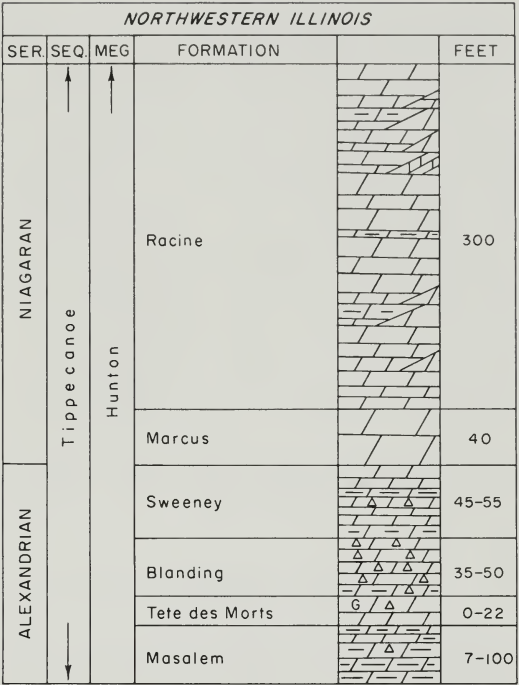


Fig. S-4—Columnar section of the Silurian System in northwestern Illinois.

reefs in northeastern Illinois contain distinctive fossils characteristic of the Guelph Formation of New York and Ontario, referred to as the Guelph fauna, or the *Megalomus* Zone. *Megalomus* is present but not common in the youngest Niagaran strata in both northeastern and northwestern Illinois. Fossils characteristic of the Guelph are also found in the top of the reef at Marine, Madison County (Lowenstam, 1949).

The Niagaran reefs are very fossiliferous and contain a great variety of invertebrates, especially stromatactis-like forms, corals, stromatoporoids, bryozoans, brachiopods, and crinoids (Lowenstam, 1949, 1950, 1957; Ingels, 1963; and others), whereas the interreef rocks are sparsely fossiliferous and the fauna, principally sponges, crinoids, and brachiopods, differs in many aspects from that of the reefs (Lowenstam, 1948a).

Fig. S-2—Exposures and textures of Silurian rocks.

- A—Massive dolomite in the core of a Racine (Niagaran) reef, at the top of the Material Service Corporation (Stearns) quarry on Archer Avenue at 28th Street, Chicago.
- B—Steeply dipping, well bedded dolomite forming the flank of a Racine (Niagaran) reef, in the Material Service Corporation quarry at Thornton, Cook County.
- C—Massive Marcus Dolomite in a quarry 3 miles east of Fulton, Whiteside County.
- D—Massive Tete des Morts Formation overlying the Mosalem Formation at the top of Silurian escarpment, 4 miles southeast of Galena, Jo Daviess County.
- E—Mottled, porous, pure dolomite characteristic of Racine reef facies in the Chicago area (×1).
- F—Dense, argillaceous dolomite containing chert nodules characteristic of Racine interreef facies in the Chicago area. The outer, porous parts of the nodules are blackened by air pollutants.

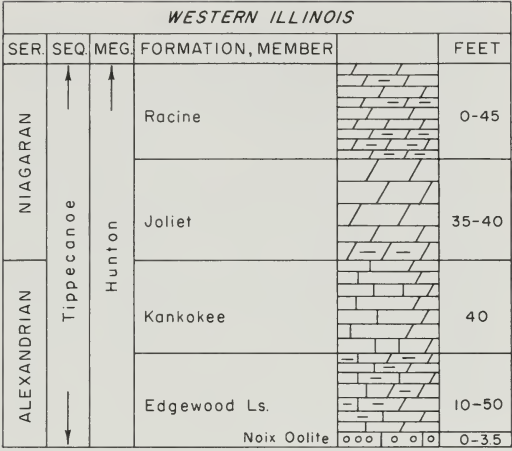


Fig. S-5—Columnar section of the Silurian System in western Illinois.

HUNTON LIMESTONE  
MEGAGROUP

The Hunton Limestone Megagroup (Taff, 1902, p. 3; Swann and Willman, 1961, p. 478), named for the former hamlet of Hunton, Coal County, Oklahoma, comprises dominantly carbonate rocks of Silurian and Devonian age that in Illinois lie between the late Ordovician clastic rocks (Maquoketa Shale Group) and the late Devonian clastic rocks (New Albany Shale Group) at the base of the overlying Knobs Megagroup (fig. 14). In local areas, siltstone and shale in the base of the Silurian System are not included in the megagroup, whereas limestone in the uppermost

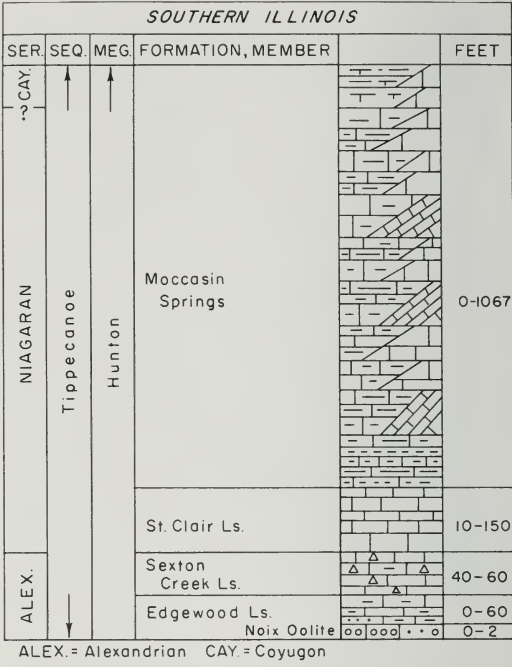


Fig. S-6—Columnar section of the Silurian System in southern Illinois.

Ordovician strata is included. At the top of the Hunton, shale of Middle Devonian age, locally present, is excluded, but basal Upper Devonian limestone is included.

Hunton strata occur throughout most of Illinois, but are absent in the central northern region and in small areas in western and southern Illinois where Ordovician and older

Worthen 1866	Savage 1912	Savage 1916	Savage 1926	Savage 1942	Willman 1943, 1962	Berry and Boucot 1970	Willman 1973, Present
Niagara	NIAGARAN		Port Byron	Guelph	NIAGARAN	P.	Racine
			Racine	Racine		L.	
			Waukesha	Bellwood			
			Joliet	Joliet		WEN.	
	ALEXANDRIAN	Kankakee		Rockdale	ALEXANDRIAN		Joliet
			Kankakee	Brassfield		LLANDOVERY	
			Edgewood	Edgewood			
	Essex				Kankakee	Kankakee	Plaines
	Channahon	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood
							Wil.
							Birds
							Schweizer

Wil.= Wilhelmi, L.= Ludlow, P.= Pridoli, WEN.= Wenlock

Fig. S-7—Development of the classification of the Silurian System in northeastern Illinois.

Worthen 1866	Savage 1914		Savage 1926 Sutton 1935		Savage 1942		Willman 1943		Brown and Whitlow 1960		Berry and Boucot 1970		Willman 1973, Present	
Niagara			NIAGARAN	Port Byron	NIAGARAN	Port Byron	NIAGARAN	Gower	NIAGARAN	Hopkinton	LUD.	Racine	NIAGARAN	Racine
				Racine		Racine								
				Waukesha		Waukesha								
				Joliet		Joliet								
				Rockdale		Joliet								
	ALEXANDRIAN	Waucoma	ALEXANDRIAN	Kankakee	ALBION	Brassfield	ALEXANDRIAN	Kankakee	ALEXANDRIAN	Kankakee	LLANDOVERY	Kankakee	ALEXANDRIAN	Blanding
	Winston	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood	Tete des Morts	Edgewood	Tete des Morts				
								Mosalem				Mosalem		

WEN. = Wenlock LUD. = Ludlow

Fig. S-8—Development of the classification of the Silurian System in northwestern Illinois.

Worthen 1866	Savage 1909	Savage 1913	Savage 1926	Rubey 1952	Collinson, Swann, and Willman 1954	Berry and Boucot 1970	Present
Niagara			NIAG.	NIAG.	NIAG.	WEN.	Racine
			Joliet	Joliet	Joliet	LLANDOVERY	Joliet
			Kankakee	Brassfield	Kankakee		Kankakee
			Edgewood	Edgewood	Edgewood		Edgewood
	ALEXANDRIAN	Sexton Creek	Edgewood	Edgewood	Edgewood		Noix
	Edgewood	Bowling Green Noix Cyrene	Edgewood	Bowling Green Noix	Edgewood	LLANDOVERY	Edgewood
							Bowling Green Noix Cyrene
							Edgewood
							Edgewood
							Edgewood

NIAG. = Niagaran WEN. = Wenlock

Fig. S-9—Development of the classification of the Silurian System in western Illinois.

Worthen 1866, 1870	Savage 1908, 1909, 1913	Savage 1926	Weller 1940	Savage 1942	Lowenstam 1949	Pryor and Ross 1962	Berry and Boucot 1970	Present
Helderberg Niagara			Bainbridge	NIAGARAN	NIAGARAN	NIAGARAN	NIAGARAN	Moccasin Springs
			Osgood	Osgood	Osgood	Osgood	Osgood	St. Clair
			Sexton Creek	Brass- field	Brass- field	Brass- field	Brass- field	Sexton Creek
			Edgewood	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood
	ALEXANDRIAN	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood	Edgewood
	Edgewood	Girardeau	Girardeau	Girardeau	Girardeau	Girardeau	Girardeau	Girardeau
		Orchard Creek	Orchard Creek	Orchard Creek	Orchard Creek	Orchard Creek	Orchard Creek	Orchard Creek

C. = Cayugan, LLD. = Llandoverly, W. = Wenlock, L. = Ludlow, P. = Pridoli, ALEX. = Alexandrian, Gr. = Group

Fig. S-10—Development of the classification of the Silurian System in southern Illinois.

rocks are exposed. The megagroup thickens from those areas to over 1800 feet in the southeastern part of the state (fig. S-13). It varies from being almost entirely dolomite in northern Illinois to limestone in southern Illinois. It contains some thin or local noncar-

bonate units—particularly the Devonian chert units in the extreme southwestern part of Illinois, some shaly strata in the Silurian Moccasin Springs Formation, and the patchy Dutch Creek Sandstone at the base of the Middle Devonian Series.

The Hunton Megagroup includes within it the sub-Kaskaskia unconformity, along which in some areas Middle Devonian strata completely truncate Lower Devonian and Silurian strata, leaving only Middle Devonian strata in the Hunton Megagroup. In other areas, the sub-Absaroka unconformity, at the base of the Pennsylvanian System, truncates all the Devonian strata, so that the megagroup consists entirely of Silurian carbonates. In a few places the sub-Absaroka unconformity cuts out the Hunton entirely. In a small area in northwestern Schuyler County, the Upper Devonian New Albany Shale Group truncates the Hunton Megagroup and rests on the Ordovician Maquoketa Shale Group.

## ALEXANDRIAN SERIES

The Alexandrian Series (Savage, 1908, p. 110; 1916, p. 312; Weller, 1940, p. 19; Willman et al., 1967), named for exposures in Alexander County, consists of early Silurian strata including and underlying the *Microcardinalia* Zone and overlying Ordovician rocks. Alexandrian strata occur throughout most of the area of Silurian rocks (fig. S-14) and, where they fill erosional channels in the Maquoketa Shale Group, are locally as much as 150 feet thick. The Alexandrian strata were included in the Niagaran until Savage (1908) recognized that they contain a fauna older than that in the lower part of the Niagaran type section in New York (fig. S-10). At first the Alexandrian Series included only the Girardeau and Edgewood Formations, but later Savage expanded the series to include the Orchard Creek Shale below and the Sexton Creek Limestone above. Weller (1940) returned the Orchard Creek to the Ordovician, and later Willman et al. (1967) followed suggestions by several authors and placed the Girardeau, also, in the Ordovician. Alexandrian strata throughout Illinois are generally argillaceous limestone or dolomite at the base, overlain by purer glauconitic limestone or dolomite that is very cherty in some areas. The series is divisible into two parts by a zone of *Platyerella manniensis* that is present at the base of the Kankakee Formation in northeastern and western Illinois but has not been found elsewhere.

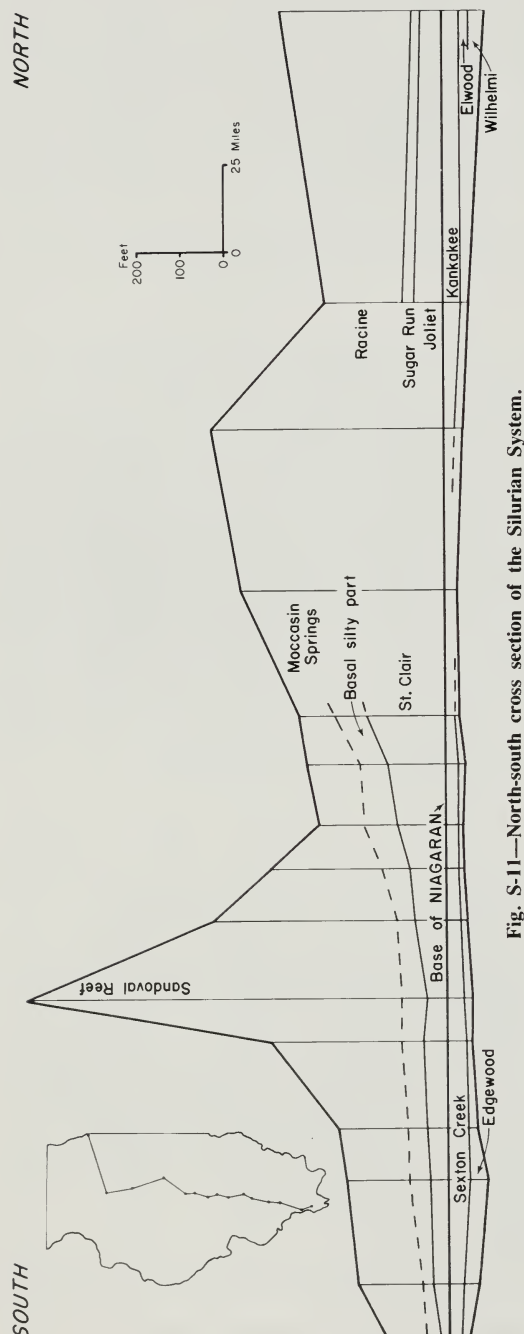


Fig. S-11—North-south cross section of the Silurian System.

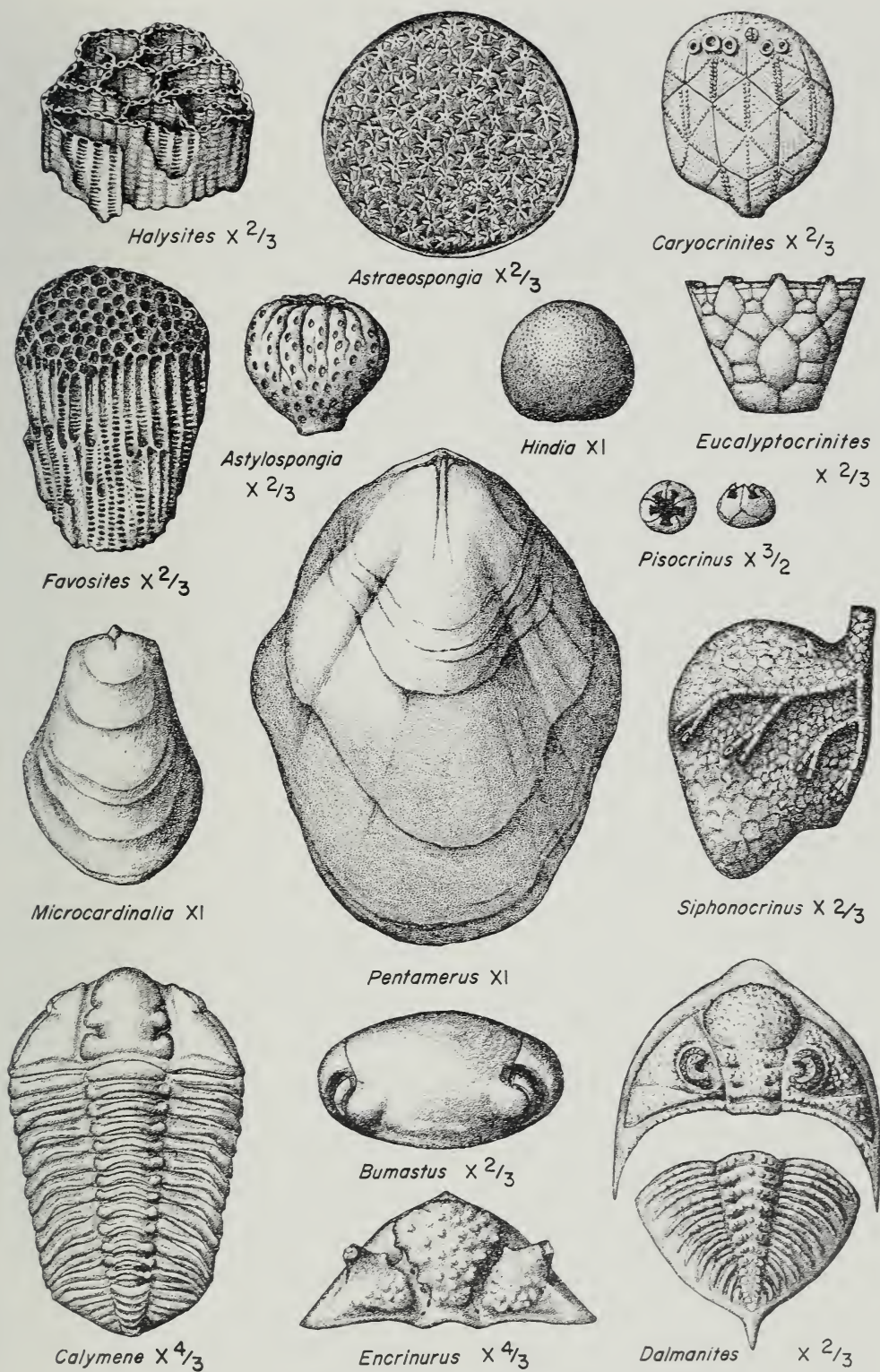


Fig. S-12—Typical Silurian fossils.



Fig. S-13—Thickness of the Hunton Limestone Megagroup (modified from Bond et al., 1971).

### Wilhelmi Formation

The Wilhelmi Formation (Willman, 1973, p. 12) is the basal formation in the Alexandrian Series in northeastern Illinois (fig. S-3) and is named for Wilhelmi Airport on the south side of Joliet, Will County, which is about 5 miles northeast of the type section (railroad cut in SE SW SE 35, 35N-9E). Earlier it had been referred to as the lower shaly part of the Edgewood Formation. It is as much as 100 feet thick where it fills deep channels in the Maquoketa Shale Group, but it is thin or absent in other areas. The lower part of the Wilhelmi Formation is medium to dark gray, very argillaceous dolomite and dolomitic shale. This unit is differentiated as the Schweizer Member and is present only where the formation is thick. The overlying moderately argillaceous dolomite, differentiated as the Birds Member, is characteristic of the relatively thin part of the formation. In some areas the basal dolomitic shale is difficult to differentiate from shale of the underlying Maquoketa Group, but the latter generally is greenish gray. The Wilhelmi is lithologically similar to the Mosalem Formation in northwestern Illinois. It probably correlates with the lower part of the Edgewood For-

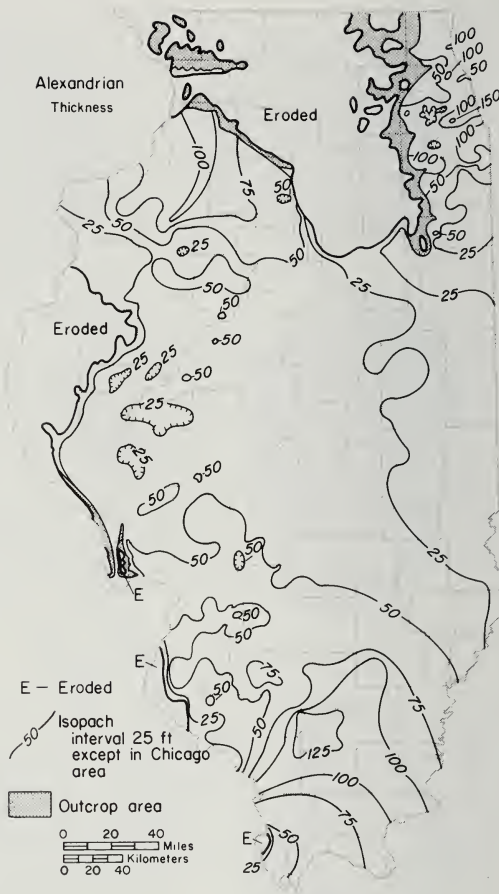


Fig. S-14—Thickness of the Alexandrian Series.

mation in western Illinois but is more argillaceous than the latter. It is absent in southern Illinois. Strata of similar lithology occur in the basal Edgewood in Iowa and are locally present in the base of the Mayville in Wisconsin and the Brassfield in Indiana and Kentucky. The Wilhelmi contains early Llandoveryan graptolites (Ross, 1962a).

**Schweizer Member**—The Schweizer Member of the Wilhelmi Formation (Willman, 1973, p. 13), the basal member, is named for Schweizer School a mile east of the type section, which is part of the type section of the Wilhelmi Formation. Although widely present in subsurface in northeastern Illinois and as much as 80 feet thick, the Schweizer Member is well exposed only in and near the type section, where it is 25 feet thick. It consists of medium to dark gray dolomitic shale at the base that grades to very argillaceous, silty dolomite at the top. A thin bed of limestone conglomerate marks the base in the type section.

**Birds Member**—The Birds Member of the Wilhelmi Formation (Willman, 1973, p. 13), which overlies the Schweizer Member, is named for the railroad siding at Birds, 2 miles northwest of the type section, which is part of the Wilhelmi Formation type section. The uppermost part of the member and its contact with the overlying Elwood Formation are ex-

posed in a ravine half a mile northeast (NW NW SE 36, 35N-9E). The Birds Member consists of 10-20 feet of slightly to moderately argillaceous, slightly cherty, thin-bedded, medium-gray dolomite. It is distinguished by several thin beds of relatively pure, finely laminated, fossiliferous dolomite.

## Elwood Formation

The Elwood Formation (Willman, 1973, p. 14), which overlies the Wilhelmi Formation in northeastern and north-central Illinois (fig. S-3), is named for the town of Elwood, Will County. The type section, which is 5 miles north of the town, lies in a ravine 3 miles southwest of Joliet, on the southeast side of the Des Plaines River Valley (NW NW SE 36, 35N-9E), where the formation is 27 feet thick. The Elwood, which previously was referred to as the upper cherty zone of the Edgewood Formation, is a slightly argillaceous, light brownish gray, thin- to medium-bedded, fine-grained dolomite that contains layers of dense white chert as much as 4 inches thick. Chert forms 40-50 percent of the upper part of the formation but is less abundant downward. Although widely present in the Joliet area, it is erratic in occurrence elsewhere. It is exposed locally along the Fox River Valley north of Aurora (SE SW 3, 38N-8E) and has been traced westward in subsurface as far as Peru, La Salle County. The abundance of chert decreases laterally, and in places equivalent beds may not be separable from the Wilhelmi Formation. In some areas, particularly in subsurface, very cherty strata previously correlated with the Kankakee Dolomite probably belong to the Elwood Formation. The Elwood Formation appears to be conformable to the Wilhelmi below and the Kankakee above. It is lithologically similar to the Blanding Formation in northwestern Illinois and to strata included in the Mayville Formation in Wisconsin.

## Kankakee Formation

The Kankakee Formation (Savage, 1916, p. 316), the uppermost formation in the Alexandrian Series in northeastern, central, and western Illinois (figs. S-3, S-5), is named for the Kankakee River in Will County, and the type section is in Cowan's Quarry and adjacent bluffs of the river 3.5 miles southeast of Richey (SE SW NW 26, 32N-10E), where the formation is 18 feet thick. The Kankakee Formation is commonly about 40 feet thick where exposed along the Des Plaines River Valley southwest of Joliet (Willman, 1973) and in subsurface elsewhere in northeastern Illinois. It has a similar thickness in exposures in Calhoun and Jersey Counties in western Illinois (Rubey, 1952), but in part of western Illinois it is completely truncated by Middle Devonian strata. In the type area the Kankakee Formation consists largely of greenish to pinkish gray, fine- to medium-grained, slightly cherty, glauconitic dolomite, generally in wavy beds 2-4 inches thick that are separated by thin green clay partings. It is differentiated into four members. The Drummond Member (at the base) is the most massive, and commonly contains a few rounded quartz sand grains and the most glauconite. The overlying Offerman Member is very thin bedded, slightly argillaceous, and weathers lighter in color than the other members. The overlying Troutman Member makes up the greater part of the formation and has the typical character of the formation. It is overlain

by the nearly white Plaines Member, which is massive except for a few thin clay partings near the base. The top of the Plaines is a distinctive, flat surface that is smooth except for small sharp-sided pits about half an inch deep that form a roughly evenly spaced pattern at 3-6 inch intervals. The pits are filled with bright green clay. This surface has been interpreted as an unconformity at the base of the Niagaran Series, but there is slight if any truncation of the Plaines Member, which is only 2-3 feet thick, and the surface is more likely a corrosion surface on which strata may be absent because of nondeposition rather than subaerial erosion. The Kankakee Formation is generally fossiliferous, and corals, particularly *Halysites* and *Favosites* (fig. S-12), are common to abundant throughout the formation (Savage, 1926). Although the basal Drummond Member contains the *Platyerella* Zone, these fossils are also locally common in the upper few feet of the underlying Elwood Formation. The Plaines Member at the top of the formation contains the *Microcardinalia* Zone where that fossil, along with *Pentamerus oblongus* (fig. S-12), occurs in dense clusters, most commonly in the lower part of the member and occasionally as scattered individuals in the Troutman Member below. The Kankakee Formation is traced in subsurface from the type region to exposures in Calhoun and Jersey Counties in western Illinois, where the formation is somewhat purer and the wavy bedding and green clay partings are less conspicuous. The formation varies from fine-grained, gray limestone in the north part of the western Illinois outcrop area to porous brown dolomite in the south part. The Kankakee is not differentiated into members in western Illinois, but the *Platyerella* Zone is present at the base and the *Microcardinalia* Zone at the top. The Kankakee is lithologically similar to the Sweeney Formation in northwestern Illinois. Although fossils indicate the equivalence of the Kankakee to the Sexton Creek Limestone in southern Illinois, the type Sexton Creek does not closely resemble the Kankakee. It lacks both the upper and lower faunal zones, and may be equivalent to only part of the Kankakee. The Kankakee Formation is essentially equivalent to the Brassfield of Indiana, Kentucky, and Ohio, but the Brassfield locally includes strata equivalent to the Wilhelmi and Edgewood in Illinois. The Kankakee is equivalent to the Mayville, Byron, and Hendricks Formations in eastern Wisconsin. However, the Mayville and Byron locally include strata equivalent to the Wilhelmi and Elwood Formations.

**Drummond Member**—The Drummond Member of the Kankakee Formation (Willman, 1973, p. 17), the basal member, is named for Drummond, Will County, 5.5 miles southwest of the type section in a railroad cut on the southeast side of the Des Plaines River Valley, 2 miles southwest of Joliet, Will County (NW SE SW 30, 35N-10E), where the member is 8.5 feet thick. It is as much as 11 feet thick in the Joliet area but thins to only 1 foot thick along the Kankakee River. The Drummond Member is pure, vesicular to coarsely vuggy, gray dolomite that generally contains abundant grains of glauconite, scattered grains of well rounded quartz sand, relatively large chert nodules, and large colonies of corals. The *Platyerella* Zone occurs in the lower part, with the fossils most common in lenses of chert.

**Offerman Member**—The Offerman Member of the Kankakee Formation (Willman, 1973, p. 17), which overlies the Drummond Member, is named for Offerman School, three-fourths of a mile southeast of the type section, which is in the same exposure as the Drummond Member. In the type section the member is only 2.5 feet thick, a minimum thickness, but

it more commonly is about 3 feet thick along the Kankakee River and 6-11 feet thick in quarries at Joliet, Elmhurst, and Hillside. The Offerman Member differs from the underlying and overlying members in being more argillaceous, less vesicular, and thinner bedded, and in having smoother bedding surfaces and a lighter colored weathered surface.

**Troutman Member**—The Troutman Member of the Kankakee Formation (Willman, 1973, p. 18), which overlies the Offerman Member, is named for Troutman Grove Cemetery, Will County, 2 miles south of the type section, the lower part of which is in the same exposure as the Drummond Member, whereas the upper part is in a small quarry one-fourth of a mile east (SW NW SE 30, 35N-10E). The two sections are correlated by a thin bed of white clay that occurs near or slightly above the middle of the member in both sections and also in nearly all exposures of the member in northeastern Illinois. The Troutman is 27 feet thick in the type locality but thins to 11 feet along the Kankakee River. The Troutman Member has the typical lithology of the Kankakee Formation. It contains a few widely scattered nodules of chert.

**Plaines Member**—The Plains Member of the Kankakee Formation (Willman, 1973, p. 18), the uppermost member, is named for Plains Station, a railroad switching point on the southeast side of the Des Plaines River 1.75 miles southwest of Joliet, Will County. The type section is at the top of a small quarry, where it overlies the type section of the upper part of the Troutman Member. The Plains Member is 2.2 feet thick in the type section but elsewhere is 1.5-3.4 feet thick. It is widely exposed along the Kankakee and Des Plaines Rivers. The dolomite is pure, massive, medium grained, and nearly white, and the top is the smooth surface that marks the top of the formation. The *Microcardinalia* Zone is largely in the Plains Member.

## Mosalem Formation

The Mosalem Formation (Brown and Whitlow, 1960, p. 36) is the basal formation in the Alexandrian Series in northwestern Illinois (fig. S-4) and is named for Mosalem Township in Dubuque County, Iowa. The type section, a roadcut south of the village of King (E1/2 SE 27, 88N-3E) exposes the upper 60 feet, nearly the entire thickness. Brown and Whitlow named the Mosalem and the overlying Tete des Morts as members of the Edgewood Formation, but, because they are distinctly different in lithology, Willman (1973, p. 31) made them separate formations and discontinued the use of Edgewood in northwestern Illinois. The Mosalem strata were originally named "Winston" (Savage, 1914) for exposures at the east end of the railroad tunnel at Winston, Jo Daviess County, but later were included in the Edgewood Formation (fig. S-8). The Mosalem is well exposed in many places in northwestern Illinois north of the Savanna Anticline and is as much as 100 feet thick where it fills channels eroded into the Maquoketa Shale Group. Typical thick exposures can be seen in the Mississippi River bluffs 6 miles south of Galena (SE SW SE 21, 27N-1E) and south of Pearl City, Stephenson County (NE cor. 17, 26N-6E). The formation is generally much thinner and is only 7 feet thick in Mississippi Palisades State Park north of Savanna, Carroll County (SW NE SE 28, 25N-3E). The Mosalem grades from very argillaceous, medium to dark gray dolomite and dolomitic shale at the base in the thick sections, to moderately argillaceous, fine-grained, dense, gray, yellow-brown-weathering dolomite at the top. It differs from the overlying Tete des Morts Formation in being more argillaceous and thinner bedded and in

containing a few bands of white chert nodules and several thin, pure, vesicular, fossiliferous, laminated beds. Where thin, the Mosalem is slightly to moderately argillaceous and thick bedded. The formation is largely nonfossiliferous, but Savage (1914) listed a small fauna. The Mosalem is similar in character to the Wilhelmi Formation in northeastern Illinois and probably is equivalent to part of the Edgewood Formation in western and southern Illinois.

## Tete des Morts Formation

The Tete des Morts Formation (Brown and Whitlow, 1960, p. 39) (fig. S-4), named for Tete des Morts Creek, Dubuque County, Iowa, overlies the Mosalem Formation in northwestern Illinois north of an east-west line through Hanover, Jo Daviess County. The type section is in the same exposure as the type section of the Mosalem Formation. The formation was originally designated a member of the Edgewood Formation but was later classified as a formation in Illinois (Willman, 1973, p. 33). It is the prominent cliff-forming unit at or near the top of many mounds and ridges in the Driftless Area in northwestern Illinois (fig. S-2D). The underlying Mosalem Formation and the Maquoketa Shale Group below are generally covered in the slopes below the Tete des Morts. The Tete des Morts is about 24 feet thick in the type locality, but in Illinois it is commonly about 20 feet thick, with a range of 18-22 feet, except where it thins to absence within a short distance at its southern limit. The Tete des Morts Formation is mainly pure, fine- to medium-grained, vesicular, massive, gray dolomite in which corals, particularly *Favosites*, are common. It generally contains little chert, but a persistent band of chert nodules and chert lenses occurs in a thin, slightly argillaceous, well bedded zone 1-2 feet thick 7-8 feet below the top. Scattered chert nodules occur locally in the lower part of the formation, and thin vein-like lenses of white chert are common, particularly in the upper part. Glauconite is common to abundant in the upper part and common to rare in the lower part. Weathered surfaces are deeply etched and exceptionally rough. Except for corals, fossils are scarce. The Tete des Morts most closely resembles the glauconitic Drummond Member at the base of the Kankakee Formation in northeastern Illinois, but if the nearly identical Elwood and Blanding Formations, which have conspicuous layers of chert, are equivalent, the Tete des Morts must be older than the Drummond, and it may be laterally equivalent to upper beds of the Wilhelmi Formation.

## Blanding Formation

The Blanding Formation (Willman, 1973, p. 35) (fig. S-4), which overlies the Tete des Morts Formation in northwestern Illinois, is named for the village of Blanding, Jo Daviess County, 3 miles south of the type section in the upper part of the Mississippi River bluffs (SE SW SE 21, 27N-1E), where the formation is 51.5 feet thick. The formation was originally named "Waucoma" (Savage, 1914) but later was assigned to the Kankakee Dolomite (Savage, 1926). The Blanding Formation is commonly 35-50 feet thick, and is widely exposed both north and south of the Savanna Anticline, along which it is eroded. It consists of brownish to pinkish gray, fine-

grained, slightly argillaceous to pure dolomite in 2-6 inch beds. It contains layers of white chert, most of them 1-3 inches thick and commonly separated by 4-6 inches of dolomite. In some localities chert forms 50 percent of the upper part of the formation. The cherty residuum above the Tete des Morts Formation on many of the mounds in the Driftless Area is derived from the Blanding Formation. The basal 3-8 feet of the formation at some places contains only a little chert, largely in scattered nodules. The dolomite in this basal zone is slightly more argillaceous than that above, and it may be equivalent to a thicker well bedded zone quarried for building stone, the "quarry beds," farther west in Iowa. Silicified corals are common in the Blanding, and Savage (1926) listed other fossils. The Blanding Formation is similar in lithology to the Elwood Formation in northeastern Illinois, but the latter has been traced in subsurface westward only to Peru, La Salle County, and the equivalence of the two units is not considered established.

## Sweeney Formation

The Sweeney Formation (Willman, 1973, p. 36) (fig. S-4), which overlies the Blanding Formation in northwestern Illinois, is named for the Sweeney Islands in the Mississippi River, a short distance west of the type section, an exposure in the bluffs in Mississippi Palisades State Park, north of Savanna, Carroll County (SW SE NE 33, 25N-3E), where the formation is 55 feet thick. It is also well exposed in the Mississippi River bluffs south of the Savanna Anticline and in quarries at Fulton in Whiteside County (cen. NE SW 21, 22N-3E). Savage (1926) correlated this unit with the Niagaran Joliet Formation in northeastern Illinois, but it has slight lithologic resemblance to the Joliet, is similar to the Kankakee Formation, and contains the *Microcardinalia* Zone characteristic of the upper Kankakee. The Sweeney Formation is commonly 45-55 feet thick and occurs throughout the Silurian outcrop area in northwestern Illinois, although it is eroded from most of the mounds north of Hanover. The Sweeney Formation is light pinkish to brownish gray, vesicular, pure dolomite in tight beds 1-4 inches thick with thin, green clay partings. Near the base and in a zone near the middle of the formation, the partings become thicker and are shaly. In places the formation contains no chert, but scattered nodules are not rare, and in a zone 3-5 feet thick 15-20 feet above the base the chert occurs in layers, lenses, and nodules. *Microcardinalia* and *Pentamerus oblongus* are common in this zone, generally in the chert. Silicified corals are common throughout the formation. It is equivalent to the upper part of the Hopkinton in Iowa and it is tentatively correlated with the Kankakee and the Sexton Creek Formations elsewhere in Illinois.

## Edgewood Formation

The Edgewood Formation (Savage, 1909, p. 517-518) (figs. S-5, S-6), the basal Alexandrian formation in western and southern Illinois, is named for exposures near Edgewood, Pike County, Missouri. The Edgewood is as much as 50 feet thick where exposed along the Lincoln Anticline in Calhoun and Jersey Counties, but in places it

is reduced to 10 feet or less where it is truncated by the Kankakee Formation (Rubey, 1952). The upper 33 feet is well exposed in a quarry at Monterey School, Calhoun County (NE SW 11, 12S-2W), and at Twin Springs in Pere Marquette State Park in Jersey County (NW SE 9, 6N-13W) (Collinson et al., 1954). The formation varies from a soft, fine-grained, thin- to medium-bedded, argillaceous, brown, dolomitic limestone containing disseminated fine sand in the northern part of the outcrop area, to a hard, massive, porous, brown dolomite or very dolomitic limestone in the southern part. In the northern part the lower few feet is a massive gray oolite or oolitic limestone—the Noix Oolite Member. The oolite is fossiliferous in places, but the remainder of the formation contains few fossils (Savage, 1913). The Edgewood Formation is also exposed along and near the Mississippi River in Alexander County in southern Illinois, where its maximum thickness is about 4 feet and it is locally absent. It thickens eastward in subsurface to as much as 60 feet. Good exposures occur in roadcuts near Gale (NE NE NW 4, 15S-3W) (Pryor and Ross, 1962). In that area the Edgewood is a massive, gray, crystalline limestone. The lower 2 feet is a conglomerate of pebbles from the Girardeau Limestone, mixed with oolites and fine quartz sand in a clear calcite matrix. The oolitic bed is assigned to the Noix Oolite Member. The oolite is also locally present in subsurface throughout southern Illinois.

**Noix Oolite Member**—The Noix Oolite Member of the Edgewood Formation (Keyes, 1898, p. 59, 62) is named for exposures along Noix Creek near Louisiana, Pike County, Missouri. It is generally at or close to the base of the Edgewood Formation but is lenticular and absent in some areas. It commonly is 1.5-3.5 feet thick in western Illinois (Rubey, 1952), and it is as much as 2 feet thick in southern Illinois (Pryor and Ross, 1962).

## Sexton Creek Limestone

The Sexton Creek Limestone (Savage, 1909, p. 518; Ulrich, 1911), which overlies the Edgewood Formation in southern Illinois (fig. S-6), is named for exposures in the Mississippi River bluff at the mouth of Sexton Creek in Alexander County (SW 27, 14S-3W), where it is about 40 feet thick, but it is best exposed 4 miles northeast, just north of the mouth of Dongola Hollow (SW SE NW 12, 14S-3W). It was originally defined to include higher strata, now differentiated as the St. Clair Limestone, but was restricted to its present boundaries by Ulrich (1911). The Sexton Creek locally truncates the Edgewood Limestone to rest directly on the Girardeau Limestone. The Sexton Creek and its contact with the Edgewood Limestone are exposed in a roadcut a quarter of a mile southeast of Gale (NE NE NW 4, 15S-3W) (Pryor and Ross, 1962). The formation is a thin-bedded, fine-grained, cherty, gray limestone. The upper part is thicker bedded and is mottled red. In the areas where it is relatively thick, the Sexton Creek commonly contains persistent bands of black chert nodules. The formation is correlated with the Kankakee Formation in northern Illinois on the basis of its fossils, although the faunal zones that mark the top and bottom of the Kankakee Formation have not been found in the Sexton Creek. The Sexton Creek is approximately equivalent to the Brassfield Limestone in Indiana and Kentucky.

## NIAGARAN SERIES

The Niagaran Series (Hall, 1842, p. 57; Swartz et al., 1942, chart 3) is based on the Niagara Falls section in New York, as restricted by differentiation of the pre-Clinton strata as the Alexandrian Series (Savage, 1908, p. 434). It consists of the strata above the *Microcardinalia* Zone (*Stricklandinia* or *Stricklandia* Zone of early reports) up to and including the faunal zone characteristic of the Guelph Formation in New York and Ontario, which is commonly identified as the *Megalomus* Zone. According to Berry and Boucot (1970, pl. 2), the Niagaran in Illinois is equivalent to most of the Upper Llandovery, the Wenlock, the Ludlow, and part of the Pridoli Series in Europe (figs. S-7 to S-10). Niagaran strata crop out in all four outcrop areas of Silurian rocks in Illinois (fig. S-1) and are present in subsurface throughout most of the Illinois Basin (S-15). They are overlain by the Cayugan Series only in southern Illinois, where the position of the top of the Niagaran is not definite but at present is placed in the upper part of the Moccasin Springs Formation. Elsewhere in Illinois the top of the Niagaran Series is truncated by Middle Devonian or younger strata. Niagaran strata have a maximum thickness of a little more than 1000 feet in Marion County, where the Sandoval Reef stood high above the surrounding interreef Niagaran (fig. S-11). Three facies were recognized in the Niagaran strata by Lowenstam (1949). A dominantly shaly facies (Bainbridge Group) occurs in the southern part of the state and also surrounds numerous reefs in the northern part of that area. A facies of intermediate purity (Thorn Group) extends from western Illinois to the Chicago region, and in it the reefs are surrounded by cherty, generally silty dolomite. A relatively pure facies (Coe Group) occurs in northwestern Illinois where the reefs are surrounded by dolomite that is generally purer than it is in the other facies. These units are at present recognized as facies, not groups, and different rock-stratigraphic classifications are used within the three facies (figs. S-3 to S-6). The boundary between the southern and northern facies is transitional through a broad zone entirely in subsurface, but, for practical purposes of changing nomenclature, it is placed at the northern boundary of the area in which a distinctive electric log marker, the "two-kick, three-kick zone," can be recognized (figs. S-1, S-16). The position of the boundary of the northwestern facies is not as well known and

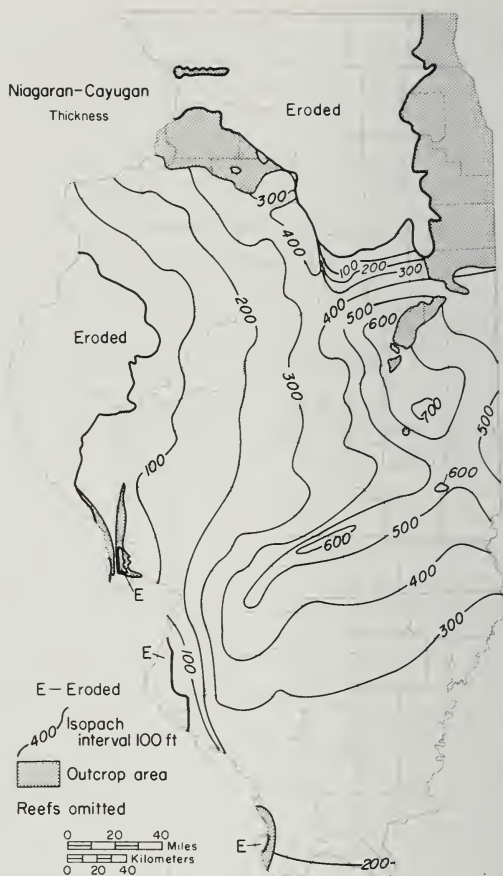


Fig. S-15—Thickness of the Niagaran Series; includes the Cayugan Series in southern Illinois.

the rock-stratigraphic units have not as yet been traced far from the outcrop area.

### Joliet Formation

The Joliet Formation (Savage, 1926, p. 522) (figs. S-3, S-5) is named for Joliet, Will County, and the type section is in the National Stone Company quarry on the south side of Joliet (NE SE 21, 35N-10E), where the formation is 68 feet thick. The Joliet Formation is differentiated as the basal formation of the Niagaran Series in an area extending from Chicago to Calhoun County in western Illinois (fig. S-1). It is 70-80 feet thick in exposures along the Des Plaines River Valley, but only about 40 feet along the Kankakee River. It is 35-40 feet thick along the Mississippi River at Grafton in Jersey County, but farther west the top is truncated by Middle Devonian strata, and in southern Calhoun County the formation is entirely eroded. In exposures in northeastern Illinois along the Des Plaines, Kankakee, Du Page, and Rock Rivers, the Joliet Formation is differentiated into a basal shaly, red, green, and gray member (the Brandon Bridge



along the Kankakee River to 34 feet thick in a quarry at Elmhurst in Du Page County. The member consists of light gray to white, gray-weathering, pure, vesicular, thin- to medium-bedded dolomite, commonly with tight stylolitic bedding surfaces. It locally has pink mottling. It contains silicified fossils and several bands of chert nodules in the type locality, but in many exposures it exhibits little or no chert. Corals are common and locally abundant.

### Marcus Formation

The Marcus Formation (Willman, 1973, p. 37) is the basal Niagaran unit in northwestern Illinois (fig. S-4). It is named for Marcus, Carroll County, 4 miles northwest of the type section, which is in an abandoned quarry in the southern part of Mississippi Palisades State Park (SW SE SE 33, 25N-3E), where it is 40.3 feet thick. It was differentiated as the "*Pentamerus* beds" in early studies and later was named "Waukesha" (Savage, 1926). The Marcus Formation occurs in northwestern Illinois both north and south of the Savanna Anticline, along which it is eroded. North of the anticline it occurs only in the deepest part of the syncline, but it extends eastward to Shannon, Carroll County, and is well exposed north of Mt. Carroll, Carroll County (SE NW NW 25, 25N-4E). South of the anticline it is well exposed in quarries east of Fulton (SW NE NW 19, 22N-4E). The Marcus is uniformly close to 40 feet thick. It consists of pure, vesicular, brown, massive dolomite (fig. S-2C). The lower 10-20 feet is generally crowded with the shells of *Pentamerus oblongus* (fig. S-12), which is also common in the upper part along with other fossils, especially corals. The Marcus Formation occurs at the position occupied by the Joliet Formation farther east and south, but it does not resemble it lithologically, and strata equivalent to the Marcus may be missing at the corrosion surface that marks the base of the Joliet. The abundance of *Pentamerus* suggests correlation of the Marcus with the Schoolcraft in Wisconsin and the Reynales in New York.

### Sugar Run Formation

The Sugar Run Formation (Willman, 1973, p. 22), which overlies the Joliet Formation in northeastern Illinois (fig. S-3), is named for Sugar Run, a stream on the south side of Joliet, Will County, along which it is well exposed. The type section, just south of the stream, is in the National Stone Company quarry, which is also the location of the type section for the Joliet Formation. The lower 26 feet of the Sugar Run is exposed at the top of the east face of the quarry. The Sugar Run strata, informally called the "building stone beds," were originally included with overlying interreef Racine strata in the Waukesha Formation (Savage, 1926), but later the Waukesha was restricted to the lower beds (Willman, 1943) (fig. S-7); recently Waukesha was replaced with Sugar Run (Willman, 1973). The Sugar Run Formation is about 30 feet thick in the Joliet area and its contact with the overlying Racine Formation is exposed on the north side of Joliet, particularly where State Highway 4A ascends the east bluff of the Des Plaines Valley (NW NW SE 34, 36N-10E). The Sugar Run Formation is exposed along the Des Plaines River from Joliet to Sag Bridge, in quarries at Elmhurst and Hillside, along the Du Page River at Naperville, along the Fox River Valley at Aurora and Batavia, and along the Kankakee River from Rock Creek

Canyon to Wiley Creek. It is absent in subsurface in some areas, in which it may be laterally equivalent to interreef strata included in the Racine Formation. The Sugar Run is slightly to moderately argillaceous and silty, very fine-grained, dense to slightly vesicular, light greenish gray, buff-weathering dolomite that occurs in medium to thick smooth-surfaced beds. It has been extensively quarried for building stone. Rock from quarries near Lemont was called "Athens Marble" and that from Joliet was called "Joliet Marble." The basal 7 feet of the Sugar Run grades uniformly into the pure Romeo Member of the Joliet Formation below. The Sugar Run generally has few macrofossils, but trilobites, particularly *Calymene*, are found in the Lemont area and elsewhere, and a varied fauna has been described (Lowenstam, 1948a).

### Racine Formation

The Racine Formation (Hall, 1861), the uppermost Niagaran Formation in northern and western Illinois (figs. S-3, S-4, S-5), is named for exposures in quarries at Racine, Wisconsin. The quarries at Racine are in reefs, and the term "Racine" was introduced in northeastern Illinois for similar rocks (Savage, 1926, p. 524). Savage gave the name "Waukesha" to the impure cherty dolomite thought to underlie the reefs but in fact equivalent to them. He also included in the Waukesha the strata under the reefs that were used for building stone. Later, Waukesha was restricted in northeastern Illinois to the latter strata, and the overlying reef and interreef strata were combined in the Racine (Willman, 1943). At the same time the Racine was redefined to include the uppermost Niagaran strata that had been differentiated by Savage on the basis of their fossils as being equivalent to the Port Byron Formation of northwestern Illinois, although similar in lithology to the Racine. For the same reason, the term "Port Byron" was discontinued in northwestern Illinois, and Racine was extended to include the entire sequence of reef-bearing rocks. The Racine is well exposed in the Chicago area (fig. S-2A, B), especially in the large quarries at Thornton, McCook, La Grange, Hillside, and Elmhurst (Bretz, 1939; Willman, 1943, 1962, 1973; Willman et al., 1950; Lowenstam et al., 1956). In northwestern Illinois it is well exposed at the top of the Mississippi bluffs in Palisades State Park north of Savanna, in the bluffs south of Fulton to Port Byron, and at Morrison, Whiteside County (Sutton, 1935; Willman, 1943, 1973). In western Illinois it is exposed only in a small area at Grafton, Jersey County. The Racine is as much as 300 feet thick. In some areas it is almost entirely pure reef rock (fig. S-2E); in others it is largely silty or argillaceous, cherty interreef rock (fig. S-2F). In places the two types of rocks intertongue. Dark gray to black shaly beds are present locally. At Blue Island, a thickness of several feet of such beds was encountered during the digging of the Calumet Sag Channel and they have been informally called the "Blue Island beds" or "*Lecthaylus* shale" (Lowenstam, 1948a). Reefs start at various levels in the Racine. Many are well defined reefs with flank beds dipping steeply away from a central massive core. In other areas the reef bodies overlap. The Racine reef rock is exceptionally pure dolomite, largely vesicular to coarsely vuggy, medium grained and light gray to white. It commonly is mottled with various shades of gray. In some reefs, many of the vugs are filled with asphaltum. The

steeply dipping flank beds are generally pure dolomite, but some beds grade into argillaceous dolomite as the slopes diminish. The Racine reefs are highly fossiliferous. In northwestern Illinois much of the Racine consists of flat-lying, pure, reef type of dolomite, and reef structures do not appear to be as common as they are in northeastern and central Illinois. No reefs are present in the small area where the Racine is exposed at Grafton in Jersey County, western Illinois. About 45 feet of Racine is exposed at Grafton, but immediately west of there the formation is truncated by Middle Devonian strata. The interreef rocks in northeastern Illinois are largely impure, varying from moderately silty to very silty or very argillaceous, and lenticular bodies of shale are locally present on the flanks of some reefs. The interreef rocks are commonly very cherty, the chert generally in irregularly scattered nodules. The interreef rocks in many places contain beds of relatively pure dolomite, probably wash from the reefs. Near the reefs some beds have a strongly nodular character, suggesting deposition in water that was subject to frequent agitation. The Racine is equivalent to the upper part of the St. Clair and to all except the youngest part of the Moccasin Springs in southern Illinois. It is correlated with and is similar in lithology to the Gower in Iowa, the Engadine in northern Wisconsin, and the Wabash in Indiana.

### *St. Clair Limestone*

The St. Clair Limestone (Penrose, 1891a, p. 102-103) (fig. S-6), named for St. Clair Springs, 8 miles northeast of Batesville, Independence County, Arkansas, is the basal formation of the Niagaran Series in southern Illinois. It is well exposed in the Mississippi River bluffs north of the mouth of Dongola Hollow, in Alexander County (SW SE NW 12, 14S-3W). Although only 10-20 feet thick where exposed in Alexander County, it thickens northward to 80-100 feet in the deeper part of the Illinois Basin, and it is as much as 150 feet thick at its northern margin, where it grades into the Joliet and Racine Formations. The strata now included in the St. Clair were originally in the upper part of the Sexton Creek (Savage, 1909), but Weller later (1940) included them in the lower part of the Bainbridge Formation (fig. S-10). Lowenstam (1949), noting that the pink crinoidal limestone of the lower Bainbridge is almost identical to that of the St. Clair in Arkansas, extended the St. Clair to Illinois and introduced Moccasin Springs for the upper, red, shaly part of the Bainbridge and elevated Bainbridge to a group. The St. Clair consists of coarsely crystalline calcite grains and abundant pink crinoidal remains in a fine-grained limestone matrix. The amount of crinoidal debris decreases upward. The matrix contains a small amount of silt, clay, and some very fine sand. The limestone occurs in medium to thick beds and is generally free of chert. It contains an abundance of arenaceous Foraminifera. The St. Clair Limestone is thought to be equivalent to the Joliet Formation and the lower part of the Racine Formation in northern Illinois. The Brandon Bridge Member of the Joliet, like the St. Clair, contains a few thin beds of pink crinoidal dolomite and abundant Foraminifera. Pink mottling also occurs in the Romeo Member of the Joliet and locally also in the Racine. The St. Clair is correlated with the Osgood, Laurel, Waldron, and Louisville Formations in Indiana.

### *Moccasin Springs Formation*

The Moccasin Springs Formation (Lowenstam, 1949, p. 16) (fig. S-6) overlies the St. Clair Limestone in southern Illinois and is named for the village of Moccasin Springs, which is 9 miles north of Cape Girardeau, Cape Girardeau County, Missouri, and 3 miles north of the type section, a ravine in the Mississippi River bluffs (SE SE NW 24, 32N-14E). The formation is 100-130 feet thick in the outcrop area, and a thick section is exposed along Sammons Creek (Salamans on some maps), Alexander County (cen. S line 2, 15S-3W) (Pryor and Ross, 1962). The formation thickens northeastward and is commonly 160-200 feet thick, but it is as much as 400 feet thick bordering the reefs. The Moccasin Springs is dominantly red, or red- and gray-mottled, very silty, argillaceous limestone and calcareous siltstone, with shale common near the top. Beds that lack the red mottling become more abundant upward and northward. The Moccasin Springs contains numerous reefs (fig. S-1), some as much as 1000 feet thick (Lowenstam, 1949) (fig. S-11). The Moccasin Springs reefs are dominantly limestone, have well defined flank structures, and many have been large producers of oil. The interreef Moccasin Springs is differentiated into three members that have not been formally named. The lower is red- and gray-mottled shale and silty limestone that grades eastward from the outcrop area into alternating beds of mottled argillaceous limestone and red calcareous siltstone that have a characteristic and widely traceable electric log curve described as the "2-kick, 3-kick zone" (fig. S-16) throughout much of the basin and bordering the reefs. The overlying member is more uniformly red to greenish gray limestone, but it has some argillaceous and silty beds. The uppermost member is dominantly green shale, but it contains beds of red-brown siltstone and limestone. The position of the St. Clair-Moccasin Springs contact in the northern Illinois Niagaran is uncertain, and the Moccasin Springs may be equivalent to only the upper part of the Racine Formation, including and above the "*Lecthaylus* shale" that is approximately 200 feet above the base of the Racine. Ross (1962b) reported a lower Ludlovian *Monograptus* from about 50 feet below the top of the Moccasin Springs, which makes it possible that much of the formation above that position may be Cayugan in age. The interreef facies of the Moccasin Springs Formation is similar to the Mississinewa Shale Member of the Wabash Formation in Indiana and the Henryhouse Formation in Arkansas and Oklahoma.

### CAYUGAN SERIES

The Cayugan Series (Clarke and Schuchert, 1899; Swartz et al., 1942, chart 3) is based on the Cayugan Group of New York and includes all the strata of Silurian age above the contact of the Guelph and Salina Formations in the New York type section. As the uppermost Racine strata in northern Illinois have been correlated with the Guelph Formation, no Cayugan age strata are recognized in that area. However, the generally accepted interpretation that the reefs isolated the basin in which the Salina evaporites accumulated in-

troduces the possibility that some of the highest reefs may have continued to grow in Cayugan time. Reefs of Cayugan age could have been eroded from Illinois before they were overlapped by Middle Devonian strata. In the deeper part of the Illinois Basin, the Moccasin Springs Formation appears in places to grade upward into the Bailey Formation, which is largely of Lower Devonian age (Collinson and Schwalb, 1955), but in the

outcrop area in Illinois the contact is sharp (Pryor and Ross, 1962). As the conodonts suggest that the lowermost beds of the Bailey are upper Silurian (Collinson, 1967), the Cayugan Series probably includes the upper part of the Moccasin Springs and the lower part of the Bailey Formation. Late Silurian graptolites have been reported from strata equivalent to the upper part of the Moccasin Springs in Missouri (Berry and Satterfield, 1972).

## DEVONIAN SYSTEM

*Charles Collinson and Elwood Atherton*

The Devonian System (Sedgwick and Murchison, 1839), named for Devonshire, England, may originally have covered all of Illinois, but if so it was eroded from the northern part of the state, largely before Pennsylvanian time (fig. D-1). The upper and lower boundaries of the system in Illinois have been controversial, but in recent years they have become more precise, mainly because of zonation of the conodonts (Collinson, 1961, 1967; Collinson et al., 1971). The lower boundary is now placed in the lower part of the Bailey Formation rather than at its base (fig. D-2). The upper boundary is placed as high as the lower few feet of the otherwise Mississippian Hannibal Formation or, where those beds are missing, on the top of the Louisiana Limestone or the Saverton Shale. In many earlier reports, the upper boundary was placed as low as the top of the Cedar Valley Limestone or the Lingle Limestone, thus putting nearly all the New Albany Shale Group into the Mississippian System.

The Devonian is less than 100 feet thick in a large part of central and western Illinois, but it thickens into the deep part of the Illinois Basin to more than 1800 feet thick (fig. D-1). It is exposed only in limited areas along and near the Mississippi and Ohio Valleys, principally where the valleys truncate anticlinal areas (fig. D-3).

The Devonian System is subdivided into three series, Lower, Middle, and Upper. It is the only system in Illinois for which these terms have not been replaced by geographic

names. Major stages in the development of the classification are shown in figures D-4 and D-5. The development of separate classifications for the northern and southern parts of the state results from the rise of the Sangamon Arch (fig. D-10) across north-central Illinois during, or at least by the end of, Lower Devonian time. Because the Sangamon Arch, rather than the Mississippi River Arch (fig. 12), formed a barrier in the Middle Devonian seas, the formations deposited in central and southern Illinois differ from those in northwestern Illinois. During late Devonian time, the Sangamon Arch subsided, and the seas spread entirely across the area.

The Lower Devonian rocks are dominantly siliceous limestone, dolomite, and chert; the Middle Devonian strata are largely pure limestone and dolomite; and the Upper Devonian sediments are dominantly black, gray, and green shale, although smaller amounts of limestone and siltstone are present. The Lower and Middle Series, with the underlying Silurian carbonates, compose the Hunton Limestone Megagroup, whereas the overlying clastic rocks form the basal part of the Knobs Megagroup (fig. D-2).

The large amount of silica in the Lower Devonian formations appears to have originated partly as finely divided quartz silt that was physically transported to the seas, and partly as a product of intensive weathering of the bordering upland areas, of transportation to the seas in solution, and of deposition as primary or diagenetic chert.

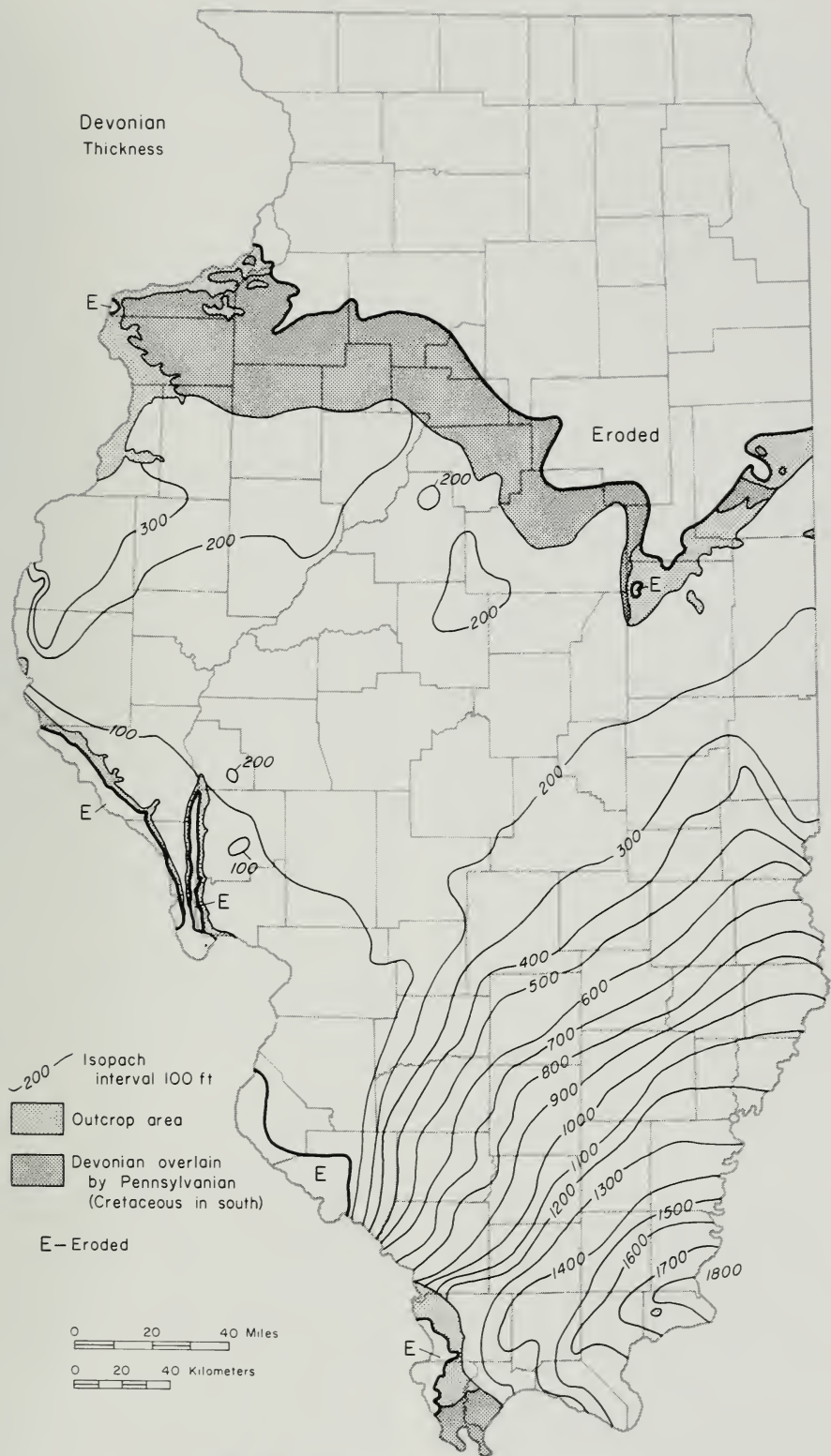


Fig. D-1—Thickness of the Devonian System.

Ser.	NORTH and WEST					SOUTH and EAST										
	Seq.	Mg.	Gr.	Formation	Member	Seq.	Mg.	Gr.	Formation	Member						
UPPER	↑	↑	↑	Louisiano Ls.		↑	↑	New Albany Sh.	Grassy Creek Sh.							
				Soverton Sh.												
				Grossy Creek Sh.												
				Sweetland Creek Sh.					Sweetland Creek Sh.							
				Sylamore Ss.												
MIDDLE	Kaskaskia	Hunton Limestone	Cedor Volley Ls.	Corolville	Kaskaskia			Blocher Sh.	Alto							
				Rapid					Lingle	Wolnut Grove Ls.  Rendlemon Oolite Bed Misenheimer Sh.  Tripp Ls. Howardton Ls.						
				Solon												
				Hoing Ss.												
			Davenport	Grond Tower Ls.				Tiogo Bentonite Bed  Cooper Ls. Genevo Dol. Dutch Creek Ss.								
			Spring Grove													
			Kenwood													
			Otis													
			Coggon													
			LOWER								Tippecanoe	↓			Clear Creek Chert	
															Bockbone Ls.	
															Grossy Knob Chert	
															Boiley Ls.	

Ser. = Series   Seq. = Sequence   Mg. = Megogroup   Gr. = Group

Fig. D-2—Classification of the Devonian System.

Most Middle Devonian rocks in Illinois are normal marine limestone, but north of the Sangamon Arch the normal sediments are interbedded with evaporites. By late Middle Devonian time, argillaceous sediments rich in spores and in finely disseminated organic debris were being deposited in the relatively deep seas in the southern part of the Illinois Basin, forming black, laminated, fissile shale. The conditions favoring this type of sedimentation were widespread during late Devonian

time and black sediments covered the entire basin, although at times the supply of organic material was reduced and gray and green shales were deposited. On the flanks of the positive areas, calcareous sediments accumulated and, in places, are interbedded with black shale.

Middle Devonian rocks, particularly on and near the flanks of the basin, contain beds, lenses, and “floating grains” of quartz sand (Summerson and Swann, 1970). Most of the

sand is well rounded and was derived by erosion from earlier Paleozoic formations (such as the St. Peter Sandstone) that were exposed on the Ozark Uplift and the Wisconsin Arch. These sands are thin and discontinuous but they are present throughout the basin. A thin bed of bentonite, the Tioga Bentonite, that originated from volcanoes in the eastern United States is widely traceable in late Middle Devonian rocks.

Fossils are common in only a few local beds of the siliceous Lower Devonian rocks, but they are common to abundant in the normal marine Middle Devonian limestones. Brachiopods and corals are the most common and best preserved of the macrofossils (figs. D-6, D-3E). Virtually no fossils are found in the widespread hypersaline limestones. In the Upper Devonian Series, macrofossils are abundant in the limestones but sparse in the shales. However, *Tasmanites* are abundant and conodonts are common to abundant in the series. The ranges of many Devonian fossils are given by Collinson et al. (1967a).

In the Illinois Basin, sedimentation was continuous from Silurian into Devonian time and from Devonian into Mississippian time. The major unconformity in the Devonian System is at the base of the Middle Devonian, where an extensive unconformity resulted from regional uplift, withdrawal of the seas, and minor warping. As a result, the Middle Devonian Series successively overlies Lower Devonian, Silurian, and Ordovician strata (fig. D-7) along what is termed the sub-Kaskaskia unconformity—the base of the Kaskaskia Sequence.

The regional correlations of the Devonian formations of Illinois have been discussed by Weller (1944b), Cooper (1944), and Collinson et al. (1967a, b).

## LOWER DEVONIAN SERIES

As in most of the Mississippi Valley region, Lower Devonian rocks in Illinois are largely siliceous—cherty, silty limestone and dolomite, and chert formations. They have long been called the Lower Devonian Series (Bassett, 1925), although the New York terms “Helderbergian,” “Helderbergian and Oriskanian,” and “Ulsterian” have been used at times in Illinois and are still used in other regions (fig. D-5). The name “Lower Devonian” is generally applied to Devonian strata older than the Onondaga Group of the New York section. They are correlated with Em-

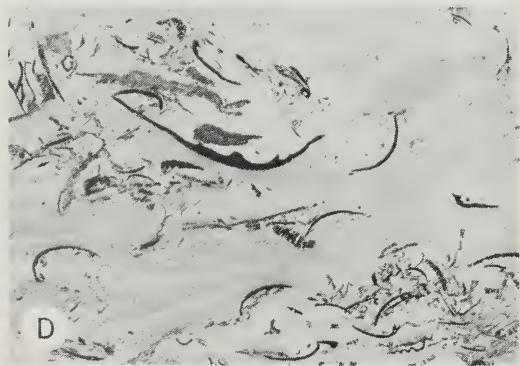
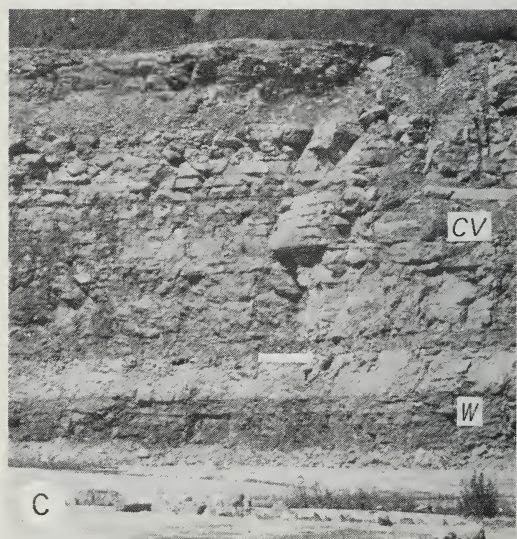
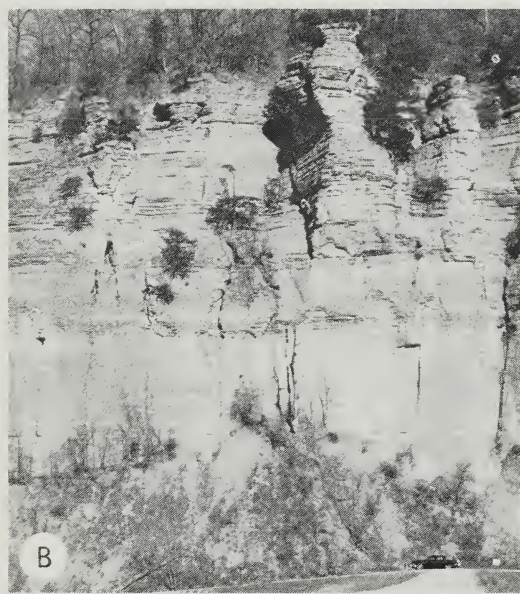
sian and older strata of Europe (Collinson et al., 1967a).

In Illinois the Lower Devonian underlies the southern third of the state, thickening southward from its northern boundary to 1200 feet in the extreme south (fig. D-8). Near the northern boundary the Lower Devonian rocks surround and partially overlap middle Silurian reefs, north of which they are truncated by the sub-Kaskaskia unconformity. They may have originally extended over all of Illinois, unless the Sangamon Arch and the positive areas bordering Illinois were above sea level during this epoch. South of the Silurian reefs, Lower Devonian strata are successively truncated by the unconformity. Along the western edge of the state, the Lower Devonian strata are truncated by the present surface on the flanks of the Ozark Uplift, and they are well exposed in Jackson, Union, and Alexander Counties (Weller, 1944a; Weller and Ekblaw, 1940; Pryor and Ross, 1962).

The Lower Devonian Series includes the Bailey Limestone (siliceous and cherty) at the base, the Grassy Knob Chert, the Backbone Limestone (pure), and the Clear Creek Chert (fig. D-9). The Bailey grades downward into the shale at the top of the Silurian Moccasin Springs Formation. Fossils are scarce in the Bailey, but the few conodonts found there suggest that the base of the Lower Devonian Series is within the lower part of the Bailey (Collinson et al., 1967a).

### *Bailey Limestone*

The Bailey Limestone (Ulrich, in Buckley and Buehler, 1904, p. 110) is named for Bailey's Landing on the Mississippi River, Perry County, Missouri, a settlement long abandoned but thought to have been at or near the village of Grand Eddy. As the original type section is not exposed, Croneis (1944) designated as a neotype the outcrops in the river bluffs at and north of Red Rock Landing, half a mile east of Grand Eddy (11, 35N-12E). The Bailey Limestone underlies much of the deep part of the Illinois Basin and it has a maximum thickness of as much as 500 feet. It is 200-300 feet thick in the Illinois outcrop area, which extends from the south line of Jackson County to Olive Branch, Alexander County. It is exposed in high cliffs in the Mississippi River bluffs, especially in the Pine Hills area in Union County about 5 miles southeast of Grand Tower, where about 400 feet of Bailey, Grassy Knob, and Backbone is exposed (fig. D-3B). The Bailey is dominantly gray to greenish gray, silty, cherty, thin-bedded, very hard limestone. Some beds are argillaceous. The chert is black to dark gray and occurs in bands of nodules and in beds, some of which are 1-2 feet thick. Beds of calcareous and silicified siltstone occur in places. In the northern area, bordering the Silurian reefs, the Bailey is less cherty and is greenish gray, argillaceous dolomite. An upper zone, 0-100 feet thick, is pure, white, coarsely crystalline, only slightly cherty



Worthen 1866	Worthen 1868	Savage 1920	Cooper et al. 1942	Workman and Gillette 1956	Collinson 1961	Present Collinson et al. 1967				
		S. Fm.	S. Fm. Mbr.	G. Fm.	S. G. Fm.	S. G. Fm. Mbr.				
Black slate	Black slate	Sweetland Creek	DEV. or MISS	Hamburg						
				Louisiana	(possibly Devonian) Champ Clark	Louisiana		Louisiana		
				Sweetland Creek		Saverton	Saverton			
						Grassy Creek	Grassy Creek			
							Sweetland Creek	Sweetland Creek		
					Sylamore	Sylamore				
Devonian Ls.	Hamilton Ls.	UPPER	ERIAN			MIDDLE				
							Cedar Valley	Coralville	Cedar Valley	Coralville
								Rapid		Rapid
								Solon		Solon
							Wapsipinicon		Wapsipinicon	Davenport
Kenwood Otis										

[illegible]

**Fig. D-5—Development of the classification of the Devonian System in southern Illinois.**

S. = Series G. = Group Fm. = Formation Mbr. = Member B. = Bed Oris. = Oriskanian Helder. = Helderbergian Sen. = Senecan Misen. = Misenheimer Bent. = Bentonite

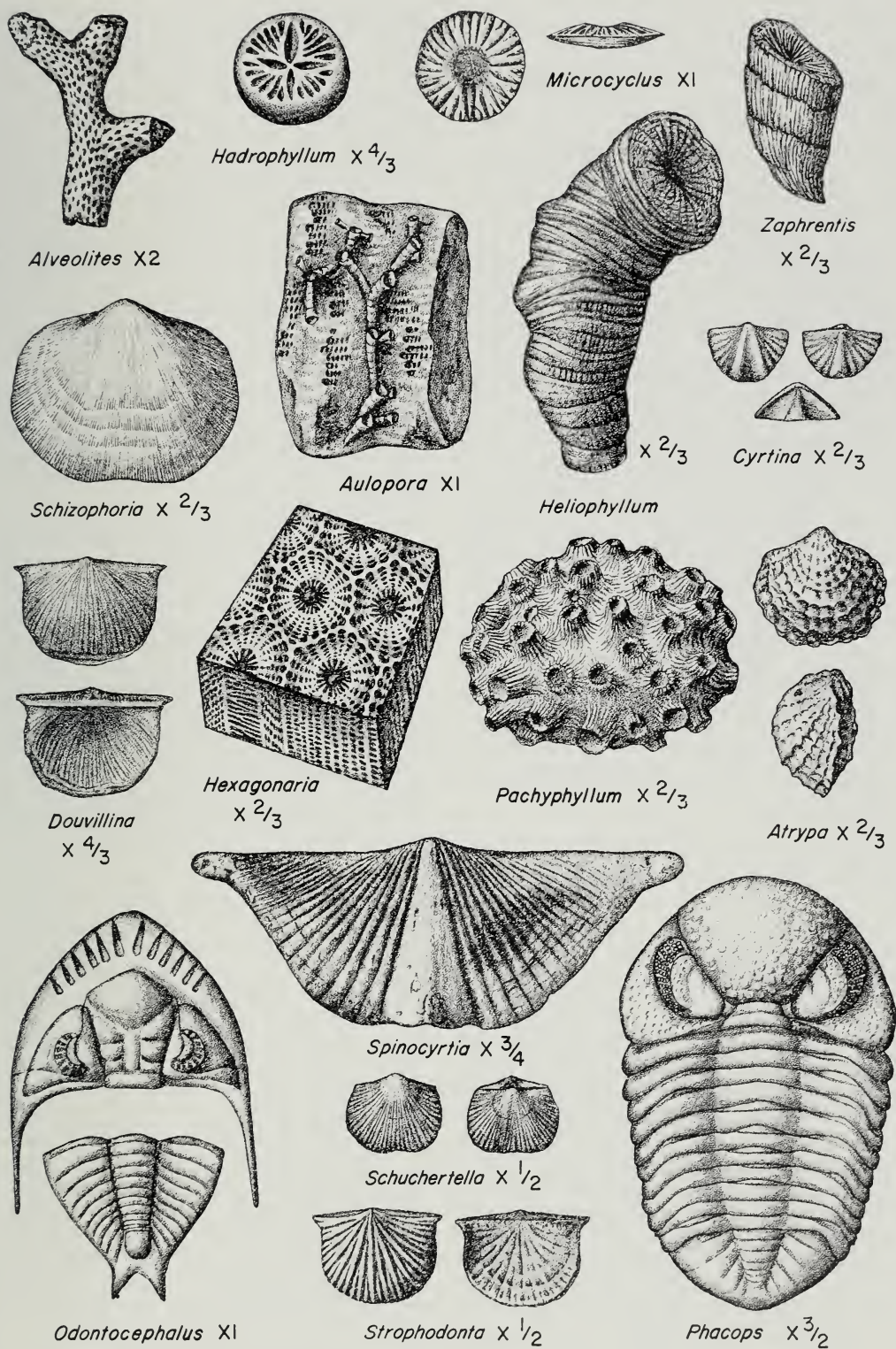


Fig. D-6—Typical Devonian fossils.

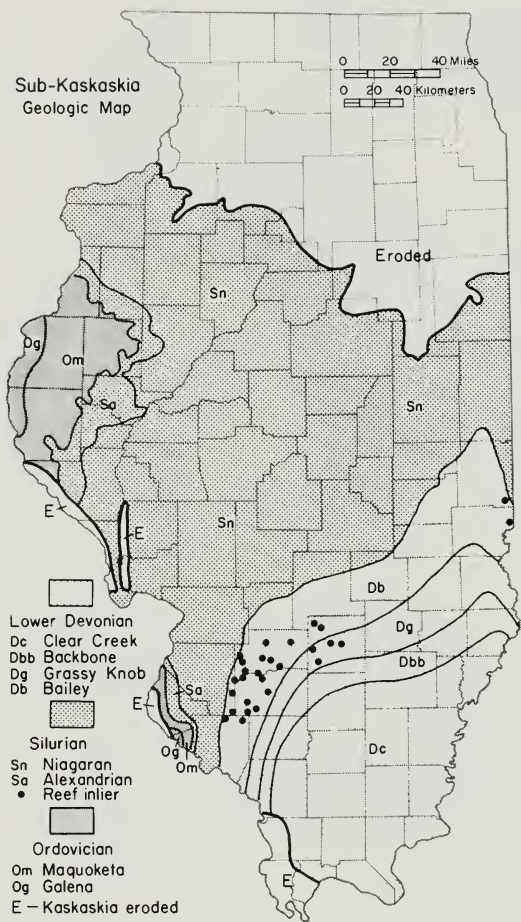


Fig. D-7—Geologic map of the sub-Kaskaskia surface.

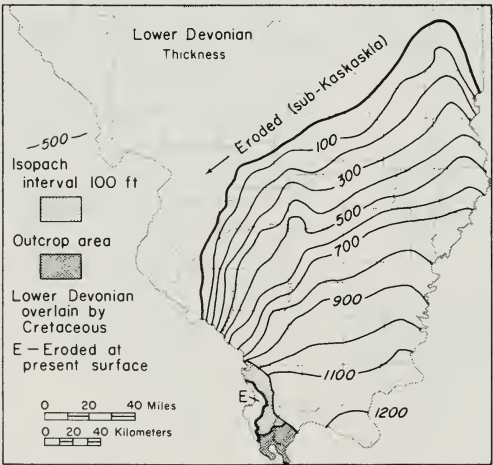


Fig. D-8—Thickness of the Lower Devonian Series.

isolated ridge called the Backbone along the Mississippi River north of Grand Tower, Jackson County. The type section is in a quarry at the south end of the ridge (SE SW SW 24, 10S-4W), where only the upper 38 feet of the formation, overlain by the Clear Creek Chert, is exposed. The Backbone Limestone appears to be as much as 200 feet thick where it rims the deep part of the Illinois Basin, but it becomes thinner within the deeper part and in places is absent (Collinson et al., 1967a). In the outcrop area in Jackson and Union Counties, the Backbone Limestone is about 100 feet thick, but it thins southward and is absent (or becomes cherty and is not recognized) in the Devonian outcrop area in Alexander County. The Backbone Limestone consists of light gray, massive, crystalline, pure limestone that commonly contains many large crinoid stems and a few scattered chert nodules. It has a large fauna that is dominated by brachiopods, notably *Acrospirifer murchisoni* and *Costispirifer arenosus*, but gastropods, bryozoans, conodonts, and trilobites are common. The fossils indicate a correlation with the Oriskany in New York. The Backbone is continuous with the Little Saline Limestone in Missouri.

Clear Creek Chert

The Clear Creek Chert (Worthen, 1866, p. 126-129; Savage, 1920, p. 174-175), the uppermost Lower Devonian formation, is named for Clear Creek in Union County, along which the formation is exposed for about 5 miles (T11-12S, R2W), although no specific type section has been designated. As originally defined by Worthen (1866), the Clear Creek may have included the Backbone Limestone and possibly the Grassy Knob Chert, but Savage (1920) restricted the name to the chert formation above the Backbone. The Clear Creek Chert is exposed along the Mississippi Valley from the south end of the Backbone in Jackson County, south to the vicinity of Tamms, Alexander County. It is well exposed in a quarry on the west bluff of Cache Valley northwest of Tamms

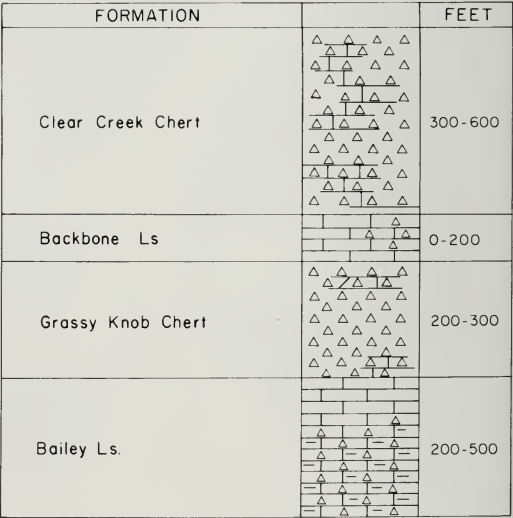


Fig. D-9—Columnar section of the Lower Devonian Series.

(NE NW 36, 14S-2W). The thickness of the Clear Creek is difficult to determine, but it is at least 300 feet thick in the outcrop area. Bald Knob, the highest point in southern Illinois, rises 600 feet above Clear Creek and appears to be all Clear Creek Chert, but the thickness is complicated by structure. The formation thickens eastward from the outcrop area to about 600 feet in the southern part of the basin. The Clear Creek is dominantly chert; much of it is white, or generally lighter in color than the chert in the lower formations (Weller, 1940). It contains some beds of gray, very fine-grained, siliceous limestone, which in places are separated from the chert beds by stylonitic partings. Such partings are also common in the chert. The proportion of limestone is generally small in most outcrops, but it is larger near the top of the formation and increases in subsurface north and east from the outcrop area. Solution of the limestone beds and fracturing of the chert beds has produced modifications of the original deposit that are variously described as novaculite, ganister, and tripoli (Lamar, 1953). The novaculite and ganister have been used for gravel and for making silica brick. The tripoli, which consists of finely divided particles of silica in vein-like bodies, is used in abrasives. The Clear Creek is much more fossiliferous than the Grassy Knob, and some chert beds are largely casts of fossils, particularly of the brachiopod *Eodevonaria melonicus*.

## MIDDLE DEVONIAN SERIES

The term "Middle Devonian Series" has been commonly used in Illinois since 1925 (Bassett), but previously the New York terms "Ulsterian," "Erian," and "Senecan" were used for these rocks. As now defined, the Middle Devonian Series is based on the boundaries established in Europe and is equivalent to the Eifelian and Givetian Stages (Collinson, 1967).

The Middle Devonian Series underlies much of the southern two-thirds of Illinois and, although commonly less than 100 feet thick in the central and western parts, it thickens to more than 400 feet in the southeastern part (fig. D-10). It is exposed in small areas in southern, western, and northwestern Illinois (fig. D-3).

In Illinois the Middle Devonian Series includes strata from the base of the Grand Tower or the Wapsipinicon to the top of the Alto or Cedar Valley Formations (fig. D-11), although evidence from the conodont fauna indicates that in some places the upper boundary may lie within the upper part of the Cedar Valley and the Blocher. Lowermost Middle Devonian rocks may be absent in Illinois because of the major unconformity at the base.

A broad, gentle arch, the Sangamon Arch (Whiting and Stevenson, 1965), extended

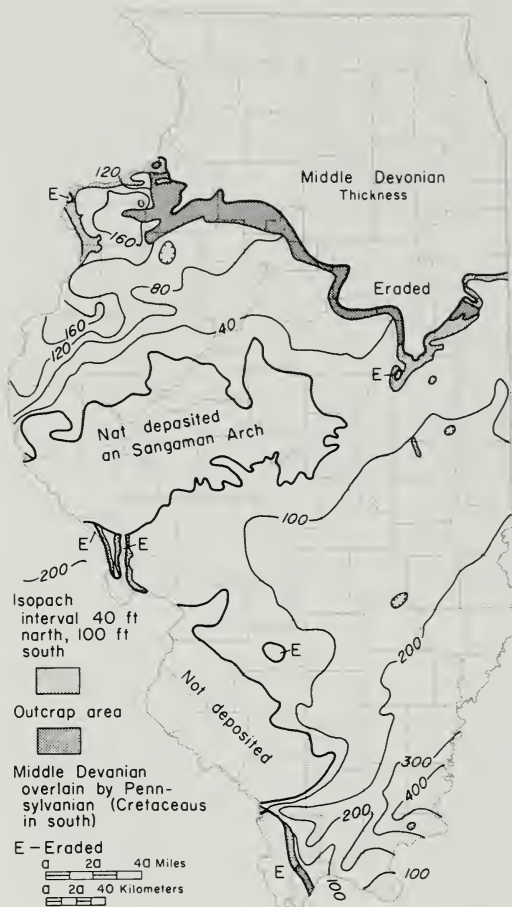


Fig. D-10—Thickness of the Middle Devonian Series.

northeast-southwest across north-central Illinois (fig. D-10) and served as a barrier in the Middle Devonian seas. The formations north of the arch were long considered to be uppermost Middle Devonian or Upper Devonian and younger than the formations south of the arch (Cooper et al., 1942), but more recent studies have indicated the general equivalence of the sediments on both sides (Collinson, 1967).

The Middle Devonian Series is dominantly limestone, although it is dolomitic in some areas. The upper part grades laterally to black shale in the deep part of the Illinois Basin, and a thin sandstone or sandy limestone occurs at the base in many areas. The top of the limestone or dolomite is the top of the Hunton Megagroup.

The Middle Devonian strata are generally very fossiliferous, and the large fauna is domi-

NORTH			
FORMATION	MEMBER		FEET
Cedar Valley Ls (5-130')	Coralville		0-25
	Rapid		50-60
	Solon		0-10
	Hoing Ss.		0-30
Wapsipinicon (0-60')	Davenport		30-50
	Spring Grove		5-25
	Kenwood		15-20
	Otis		20-30
	Coggon		0-20
SOUTH			
Alto (0-100')			
Lingle (20-150')	Walnut Grove Ls. Rendleman O.B.		0-50
	Misenheimer Sh.		0-50
	Tripp Ls.		0-80
	Howardton Ls.		0-110
Grand Tower Ls. (100-250')	Tioga Ben. B.		0-0.6
	Cooper Ls.		0-50
	Geneva Dol.		0-50
	Dutch Creek Ss.		0-30

O. B. = Oolite Bed, Ben. B. = Bentonite Bed

Fig. D-11—Columnar section of the Middle Devonian Series.

nated by brachiopods, corals, and conodonts, although other forms are common. Because of the sub-Kaskaskia unconformity, the Middle Devonian strata truncate Lower Devonian, Silurian, and uppermost Ordovician strata (fig. D-7).

## KASKASKIA SEQUENCE

The major unconformity at the base of the Middle Devonian Series, or in some areas the base of the Upper Devonian Series, is widely present throughout the eastern part of the United States, and the strata between the unconformity and the next higher major unconformity (which in Illinois is at the base of the Pennsylvanian System) are called the Kaskaskia Sequence (Sloss et al., 1949) (fig. 14). The Kaskaskia Sequence is named for the Kaskaskia River in south-central Illinois. The original definition of the sequence placed its top at the base of the Mississippian Aux Vases Sandstone, excluding the Chesterian Series. However, because the sub-Aux Vases unconformity is confined to the margin of the basin and the Chesterian strata generally have the same structural attitude as the underlying Valmeyeran Series, the Kaskaskia was extended upward to the base of the Pennsylvanian System (Swann and Willman, 1961).

### Wapsipinicon Limestone

The Wapsipinicon Limestone (Norton, 1895, p. 127, 155-166) is named for the Wapsipinicon River in Iowa, along which the type section consists of exposures between Troy Mills and Central City, Linn County, Iowa. It occurs in the basin northwest of the Sangamon Arch (fig. D-12), where it unconformably overlies Silurian and Ordovician strata (fig. D-7) and is overlain by the Cedar Valley Limestone. It has a maximum thickness of about 60 feet near the Mississippi River and thins southeastward. It lenses out on the flanks of the Sangamon Arch, where it is overlapped by the Cedar Valley Limestone. The Wapsipinicon is exposed in Illinois only in the vicinity of Rock Island, and the principal exposures are in quarries and outcrops at Milan (fig. D-3C), Rock Island, and Andalusia in Rock Island County, and at Cleveland in Henry County (Savage, 1921b; Savage and Udden, 1921; Collinson et al., 1967b; Edmund and Anderson, 1967). The Wapsipinicon is dominantly fine-grained to lithographic, pure limestone, but some beds are argillaceous and dolomitic. Beds of anhydrite and gypsum occur locally in the subsurface in the westernmost part of the area, particularly in Hancock County. They are probably equivalent to the prominent brecciated beds that occur in the outcrop sections. Pods and lenses of sandstone occur in places, especially at and near the base. In the type region six members are differentiated, but in Illinois only the upper five are recognized (fig. D-11)—the Coggon Member (cherty dolomite) at the base, the Otis Member

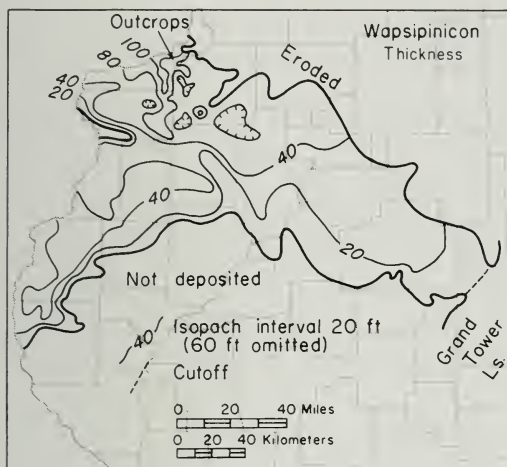


Fig. D-12—Thickness of the Wapsipicon Limestone (after James, 1968).

(lithographic limestone), the Kenwood Member (argillaceous dolomitic limestone), the Spring Grove Member (dolomite and dolomitic limestone), and the Davenport Member (lithographic limestone) at the top. The Wapsipicon apparently was deposited in hypersaline waters and fossils are very rare.

**Coggan Member**—The Coggan Member of the Wapsipicon Limestone (Norton, 1894, p. 23-24), at the base of the Wapsipicon in Illinois, is named for Coggan, Linn County, Iowa, where the type section is at the Illinois Central Railroad crossing of the Buffalo River. The Coggan Member is not exposed in Illinois, but it occurs locally in subsurface and is as much as 20 feet thick in the area between Galesburg, Knox County, and Muscatine, Iowa. It consists of massive, buff, cherty dolomite. It also contains a thin bentonite that has been correlated with the Tioga Bentonite Bed, which occurs near the top of the Grand Tower Formation southeast of the Sangamon Arch.

**Otis Member**—The Otis Member of the Wapsipicon Limestone (Norton, 1894, p. 22-24), which overlies the Coggan Member (or Silurian dolomite where the Coggan is absent), is named for the railway junction called Otis, east of Cedar Rapids, Linn County, Iowa. The Otis Member is 26 feet thick where exposed in a quarry at Cleveland, Henry County (S1/2 31, 18N-2E). It is fine-grained to lithographic, light gray to brown limestone with a few lenses of chert. In the region where it thins out on the flanks of the Sangamon Arch, lenses of quartz sandstone as much as 5 feet thick occur at the base.

**Kenwood Member**—The Kenwood Member of the Wapsipicon Limestone (Norton, 1894, p. 23; Stainbrook, 1935, p. 251), which overlies the Otis Member, is named for Kenwood Park in the northern part of Cedar Rapids, Linn County, Iowa, where the type section is an exposure along Indian Creek. As originally defined, the Kenwood included strata later differentiated as the Spring Grove Member (Stainbrook, 1935). The Kenwood is 15-20 feet thick in the outcrop area. It is 10 feet thick where exposed at the base of a quarry half a mile southeast of Milan, Rock Island County (NW 25, 17N-2W), and 16 feet in the quarry on the south side of Rock Island, Rock Island County (SE 14, 17N-2W), but the base is not exposed in either quarry. The Kenwood consists of laminated or thin-bedded, argillaceous, dolomitic limestone with strongly brecciated beds and pockets of clay.

**Spring Grove Member**—The Spring Grove Member of the Wapsipicon Limestone (Stainbrook, 1935, p. 251-252) formerly was the upper part of the Kenwood. It is named for Spring Grove Township, Linn County, Iowa, where the type section is on the right bank of the Wapsipicon River (cen. 24, 86N-7W). It is probably as much as 25 feet thick in subsurface, but it is only 5-10 feet thick in the outcrop area, where it is exposed in the quarries at Milan and Rock Island. The Spring Grove Member is brown laminated dolomite and dolomitic limestone that weathers into thin plates. It is non-fossiliferous.

**Davenport Member**—The Davenport Member of the Wapsipicon Limestone (Norton, 1894, p. 24; Stainbrook, 1935, p. 252), the uppermost member, overlies the Spring Grove Member and is overlain by the Cedar Valley Limestone. It is named for Davenport, Scott County, Iowa, near which it is exposed, but no type section has been designated. As originally used, the name "Davenport" was applied to a Lower Davenport Member and an Upper Davenport Member. However, the upper, fossiliferous member was later assigned to the Cedar Valley, and the lower member was renamed the Davenport Member (Stainbrook, 1935). The Davenport is 40-50 feet thick in subsurface, but is 30 feet thick where exposed in the quarries at Milan and Rock Island and only 18 feet thick across the river near Linwood, Iowa. It consists of pure, hard, light gray to brownish gray, fine-grained to lithographic limestone. It contains many beds of limestone breccia and, in subsurface, anhydrite and gypsum. No fossils have been found in it.

## Cedar Valley Limestone

The Cedar Valley Limestone (McGee, 1891, p. 314), named for the valley of Cedar River, Iowa, overlies the Wapsipicon Limestone and underlies the New Albany Shale Group of the Upper Devonian Series. No type section has been designated. The Cedar Valley underlies a large area in north-central and northwestern Illinois (fig. D-13). It is exposed in the Rock Island area where the Mississippi River and its tributaries have cut into the Mis-

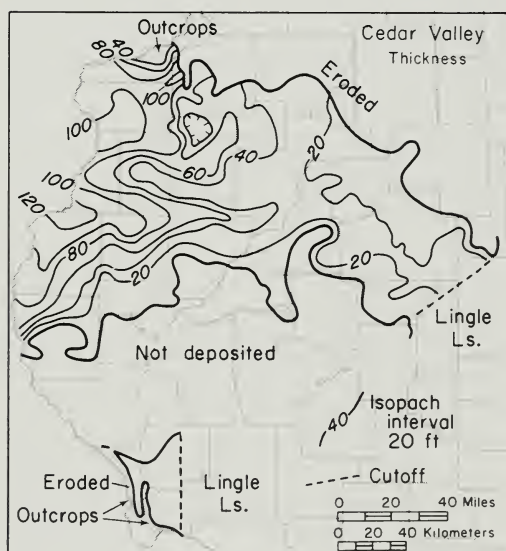


Fig. D-13—Thickness of the Cedar Valley Limestone (after James, 1968).

Mississippi River Arch (fig. D-3C). Southward, the Cedar Valley overlaps the Wapsipinicon Limestone and thins out on the flank of the Sangamon Arch, except at the northeastern and southwestern ends of the arch where the Middle Devonian seas temporarily covered the arch, and the Cedar Valley sediments are continuous with strata included in the Lingle Limestone. The strata deposited immediately south of the southwestern part of the Sangamon Arch are exposed in Calhoun and Jersey Counties, and, because they are more like the Cedar Valley than the Lingle, the name Cedar Valley has long been used in that area (Rubey, 1952). The Cedar Valley has a maximum thickness of about 130 feet in the subsurface in Hancock County, but it generally thins to the east and south (fig. D-13). It is about 60 feet thick in exposures near Rock Island. In the Calhoun and Jersey County outcrops it is 4-40 feet thick, but in most of the area it is less than 15 feet thick. The Cedar Valley is largely a highly fossiliferous, crystalline, light gray limestone (fig. D-3D), but it contains some fine-grained, argillaceous beds, thin shaly partings, and sandstone. In the northern outcrop area it is subdivided into four members—the Hoing Sandstone Member at the base, the Solon Member (pure, very fossiliferous), the Rapid Member (argillaceous, partly fossiliferous), and the Coralville Member (pure, very fossiliferous) at the top. In the area south and southwest of Rock Island, the Cedar Valley is medium-grained, detrital limestone that in Hancock and Adams Counties locally contains fine-grained, rounded quartz sand. The Solon and Rapid Members are not differentiated in that area. In the southern outcrop area the Cedar Valley grades from brown, thin-bedded, fine-grained, cherty, argillaceous, sandy limestone at the base to thick-bedded, pure, crystalline, highly fossiliferous limestone in the upper part. The Cedar Valley apparently has conformable relations to the Wapsipinicon below. Its sharp erosional contact with the New Albany above indicates a minor unconformity, although the faunal evidence indicates only a brief interruption in sedimentation. In places the Cedar Valley is overlain unconformably by Pennsylvanian strata. The fauna of the Cedar Valley is very large (Savage, 1920, 1921b; Cooper and Cloud, 1938; Rubey, 1952; Collinson and Scott, 1958b; and others) and is characterized by abundant brachiopods and corals (fig. D-6). The Cedar Valley has a large conodont fauna that indicates the Upper Devonian age of the uppermost beds in some areas. In general, the fauna correlates the Cedar Valley with Hamilton strata in New York and the upper part of the North Vernon Limestone in Indiana (Collinson et al., 1967b).

**Hoing Sandstone Member**—The Hoing Sandstone Member of the Cedar Valley Limestone (Hinds, 1914, p. 12), the basal member, was originally called the “Hoing oil sand” for its occurrence in a well on the Hoing Farm, near Colmar, McDonough County, the discovery well of the Colmar-Plymouth oil field (Blatchley, 1914). It was called the Hoing sand, or the “Hoing” sandstone, until formally designated the Hoing Sandstone (Howard, 1961). The Hoing is patchy in western Illinois. Although it is commonly only a few inches thick, it reaches 30 feet thick in the Colmar-Plymouth oil field. Where well developed it is a clean, friable sandstone composed of well rounded, fine to medium quartz grains. However, where it directly overlies the Silurian dolomite it commonly contains residual debris from erosion of the dolomite. At the exposure at the Monterey School, Calhoun County (NE SW 11, 12S-2W), the Hoing Member is 0-2 feet thick and consists of sandstone, shale, and chert con-

glomerate overlying the deeply eroded Silurian dolomite (Collinson et al., 1954). Thin lenses of sand also occur locally higher in the Cedar Valley Limestone.

**Solon Member**—The Solon Member of the Cedar Valley Limestone (Norton, 1897, p. 148; Keyes, 1913, p. 205-206), the basal member where the Hoing is not present, is named for Solon, Johnson County, Iowa, but no type section has been designated. In Illinois the Solon Member has a maximum thickness of about 10 feet but is absent locally. It is 6-8 feet thick where exposed in quarries southeast of Milan and on the south side of Rock Island. It is a fine- to medium-grained, grayish brown, very fossiliferous limestone with brecciated beds. It is characterized by an abundance of brachiopods, mainly *Atrypa independensis*, and corals, notably biostromes of *Hexagonaria profunda* (fig. D-6). Conodonts also are abundant and indicate correlation with the upper Hamilton in New York (Collinson et al., 1967b).

**Rapid Member**—The Rapid Member of the Cedar Valley Limestone (Keyes, 1912, p. 149; 1913, p. 205-206), which overlies the Solon, is named for a locality in Johnson County, Iowa, not specified by Keyes. The Rapid is the most widespread and thickest member. It is as much as 60 feet thick in the Rock Island area, but it thins to the east and south. It forms the upper 53 feet of the quarry southeast of Milan. The member consists of gray to buff, fine-grained, argillaceous, locally dolomitic limestone. Most of it is thick bedded, but the upper and lower parts are thin bedded and have shaly partings. Some beds, especially near the top and bottom, are very fossiliferous. Brachiopods and corals are most common, particularly *Atrypa*, *Stropheodonta*, *Chonetes*, *Spirifer*, *Schizophoria*, *Pentamerella*, *Hexagonaria*, *Favosites*, and *Helio-phyllum* (Edmund and Anderson, 1967) (fig. D-6). Conodonts indicate a late Middle Devonian age (Collinson et al., 1967b).

**Coralville Member**—The Coralville Member of the Cedar Valley Limestone (Keyes, 1912, p. 149; 1913, p. 205-206), the uppermost member, is named for Coralville, Johnson County, Iowa, and the type section is in quarries 1 mile northeast of Coralville. The Coralville is present in Illinois only in the western part of the area of the Cedar Valley. It is as much as 25 feet thick and is unconformably overlain by the Sweetland Creek Shale of the New Albany Group. It consists of brown, medium-grained dolomite that in places is a stromatoporeid reef. The Coralville is abundantly fossiliferous; brachiopods, corals, bryozoans, and stromatoporeids are the most common fossils. The conodonts indicate that in places the boundary of the Middle and Upper Devonian Series lies within the Coralville (Collinson et al., 1967b), but most, if not all, of the Coralville in Illinois is Middle Devonian in age.

## Grand Tower Limestone

The Grand Tower Limestone (Keyes, 1894, p. 30, 42), which forms the lower part of the Middle Devonian Series in Illinois south of the Sangamon Arch, is named for Grand Tower, Jackson County (fig. D-3A). The type section, not designated by Keyes, was probably intended to be, and currently is accepted as, the exposure in the Devil's Bake Oven, an isolated hill half a mile north of Grand Tower (SW SE NE 23, 10S-4W), where the formation is 157 feet thick. The Grand Tower thins out northward against the Sangamon Arch, westward against the Ozark Uplift, and southward at the southern margin of Illinois (fig. D-14). It apparently was not deposited on the Sparta Shelf, an eastward projection of the Ozarks, but it does occur in the Wittenberg Trough, along the south side of the Sparta Shelf, and it is as much as 160 feet thick there (Meents and Swann, 1965). From the

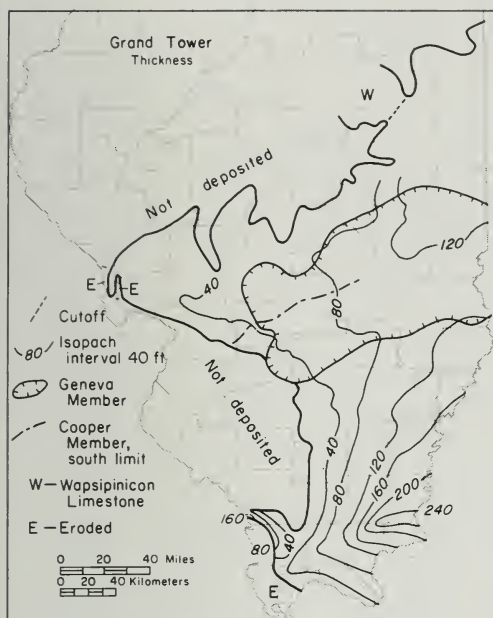


Fig. D-14—Thickness of the Grand Tower Limestone (after North, 1969).

Sparta Shelf it thickens eastward to reach a maximum of 250 feet. The Grand Tower is mostly coarse-grained, light gray, medium- to thick-bedded, cross-bedded, pure, fossiliferous limestone, but it also contains lithographic limestone, which becomes more abundant upward (North, 1969). At the base a calcareous sandstone or sandy limestone with sandstone beds is differentiated as the Dutch Creek Sandstone Member. In the central and eastern parts of the state the Grand Tower is largely dolomite, the lower part of which is brown dolomite differentiated as the Geneva Dolomite Member, and the upper part is a laminated, gray to tan, fine-grained dolomite that has not been named. In the northern part of its area, the Grand Tower is represented primarily by a light gray, lithographic limestone differentiated as the Cooper Limestone Member. A thin bentonite widely present near the top of the formation is the Tioga Bentonite Bed. The Grand Tower Limestone is abundantly fossiliferous, and a large macrofauna (S. Weller, 1897; Savage, 1920; Grimmer, 1968) and conodont fauna (Orr, 1964; Collinson et al., 1962) have been described. The base of the Grand Tower is a major unconformity—the base of the Kaskaskia Sequence—and in the northern part of its area the Grand Tower sharply overlaps the entire Lower Devonian Series and rests on the Silurian System. The Grand Tower correlates with all but the upper part of the Wapsipinicon Limestone in northern Illinois and Iowa, with the Geneva Dolomite and Jeffersonville Limestone in Indiana, and with the Onondaga in New York (Collinson et al., 1967a).

**Dutch Creek Sandstone Member**—The Dutch Creek Sandstone Member of the Grand Tower Limestone (Savage, 1920, p. 170-171, 175; Meents and Swann, 1965, p. 6) is

named for Dutch Creek, a tributary of Clear Creek in central Union County, but no type section has been designated. An exposure along a secondary road 1.1 miles northwest of its junction with Illinois Highway 127 (W $\frac{1}{2}$  NW 27, 11S-2W), about 2 miles north of Dutch Creek, has been used as a reference section (Meents and Swann, 1965). There the gradation of the member to the overlying part of the Grand Tower and the unconformable contact on the underlying Clear Creek can be seen. The Dutch Creek was originally called the Oriskany Sandstone by Worthen (1866). Because of the discontinuous nature of the sandstone and its lateral and vertical gradation to sandy dolomite or limestone, Meents and Swann (1965) restricted the Dutch Creek to localities where beds of sandstone are present and classified it as a member of the Grand Tower Limestone. The Dutch Creek is exposed at many localities in Union, Alexander, and Jackson Counties (Weller and Ekblaw, 1940), and it is present in subsurface at many places throughout the area of the Grand Tower Limestone. However, the principal occurrences are in the outcrop area and in Wayne and adjacent counties of eastern Illinois (Collinson et al., 1967a). The Dutch Creek is as much as 30 feet thick in the outcrop area but is more commonly less than 15 feet, in many areas only a foot or two thick. It is a fossiliferous, calcareous sandstone composed of well rounded, well sorted, medium to fine quartz grains. In many areas the sandstone is interbedded with sandy limestone. The abundant fauna is principally brachiopods and corals. The fossil mold of the coral *Pleurodictyum problematicum* is an especially distinctive indicator of the member. Prominent brachiopods include *Amphigenia curta*, *Rhipidomella* cf. *R. penelope*, and *Protoleptostrophia perplana*.

**Geneva Dolomite Member**—The Geneva Dolomite Member of the Grand Tower Limestone (Collett, 1882, p. 63, 81-82), named for Geneva, Shelby County, Indiana, is continuous from its type locality westward into eastern and central Illinois, where it is as much as 50 feet thick but is not exposed. In Illinois it is the basal member of the Grand Tower Limestone, wherever the patchy Dutch Creek Sandstone Member is not present, but in Indiana it is classified as a formation (Shaver et al., 1970). The Geneva is dark brown, crystalline, porous, pure dolomite. It contains finely disseminated organic material and produces oil in several fields (Schwalb, 1955). In some localities floating grains of rounded, coarse to fine quartz sand occur in the Geneva, particularly in its lower part. The Geneva is essentially nonfossiliferous but contains a few chitinozoans and scolecodonts (Collinson et al., 1967a). The member grades laterally into the lower part of the Grand Tower (Meents and Swann, 1965; North, 1969).

**Cooper Limestone Member**—The Cooper Limestone Member of the Grand Tower Limestone (Swallow, 1855, p. 108, 196) is named for Cooper County, Missouri, where it is classified as a facies of the Calloway Limestone (Koenig, 1961). In Illinois it is as much as 50 feet thick in a belt 60-90 miles wide that extends eastward across the state south of the Sangamon Arch (fig. D-14). It is exposed only in Calhoun County (Meents and Swann, 1965), where it previously was considered part of the Cedar Valley Limestone. It is sparsely fossiliferous, gray, dense, lithographic, pure limestone, but it contains scattered grains of quartz sand in some localities. On its northern margin it is overlapped by the Lingle Limestone, and on the south it grades laterally to the light-colored dolomite that overlies the Geneva Dolomite Member. It is similar to the Wapsipinicon Limestone north of the Sangamon Arch and probably is continuous with it west of Illinois.

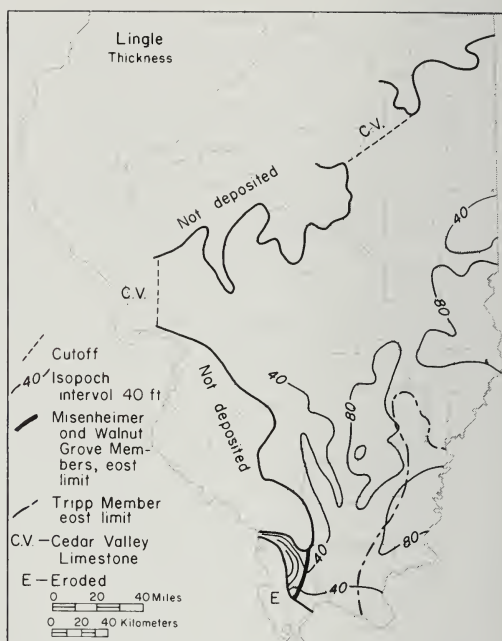
**Tioga Bentonite Bed**—The Tioga Bentonite Bed of the Grand Tower Limestone (Ebright et al., 1949, p. 10), named for Tioga County, Pennsylvania, where it was first discovered in drill cuttings from the Tioga gas field, is widely present in Illinois 10-30 feet below the top of the formation, but no outcrops have been found (Meents and Swann, 1965), except re-

cently in a quarry at Tuscola in Douglas County. Although possibly as much as 6-8 inches thick in southeastern Illinois, it most commonly is only 1-2 inches thick. Its occurrence is patchy, but it has been observed in more than 100 wells and can be recognized on sonic logs even in areas where it is only a quarter of an inch thick. It is greenish to brownish gray shale that contains biotite flakes and an abundance of mixed-layer clay minerals that distinguish it from the normal shales.

## Lingle Formation

The Lingle Formation (Savage, 1920, p. 171, 176; Weller, 1944a, p. 95-96; North, 1969, p. 14-22) is named for Lingle Creek in southern Union County. The type section is a poorly exposed outcrop on a branch of Lingle Creek (SE SW SW 26, 13S-2W). A more complete exposure occurs 3.25 miles west of Cobden, Union County (NW NE 34, 11S-2W). Because the sequence is complex and the exposures poor and widely scattered (Weller, 1940), the Lingle has been variously interpreted (fig. D-5). Savage (1920) differentiated a shale at the base—the Misenheimer Shale—as a separate formation, but Weller (1944a) included the shale in the Lingle and abandoned the name “Misenheimer.” Grimmer (1968) and North (1969) related the type Misenheimer to a shale well above the base of the Lingle and reinstated Misenheimer but made it a member of the Lingle. The Lingle occurs throughout a large area south of the Sangamon Arch, generally overlapping the Grand Tower (fig. D-15), and it has a maximum thickness of about 110 feet. The Lingle Formation is an interval of mixed limestone and shale. It is more argillaceous, more shaly, darker colored, and finer grained than the Grand Tower below, and less silty and dolomitic than the Alto Formation above. North (1969) subdivided the Lingle into the Howardton Limestone Member (argillaceous, shaly) at the base, the Tripp Limestone Member (argillaceous, silty, cherty), the Misenheimer Shale Member, and the Walnut Grove Limestone Member (cherty, very silty, glauconitic) at the top. The Walnut Grove is characterized by the Rendleman Oolite Bed near its base. Of the four members, the Misenheimer and Walnut Grove occur only near the outcrop area in southwestern Illinois (fig. D-15). North interpreted these two members and the more extensive Tripp Member below as grading laterally eastward into the New Albany Shale Group, with the Tripp Member essentially equivalent to the Blocher Shale. However, the relations are not clearly demonstrable, and faunal evidence suggests that all three members plus the overlying Alto and Sylamore Formations may be equivalent to the Blocher. Some of the Lingle strata are very fossiliferous, and both macrofossils (Savage, 1920; Grimmer, 1968) and conodont faunas (Orr, 1964) have been described. Characteristic fossils include *Microcyclus discus* (fig. D-6), *Devonochonetes coronatus*, and *Mucrospirifer mucronatus*. They relate the Lingle to the upper half of the Hamilton in New York (Collinson et al., 1967a).

**Howardton Limestone Member**—The Howardton Limestone Member of the Lingle Formation (North, 1969, p. 22-25), the basal member, is named for Howardton, Jackson County, 2 miles east of the type section, which is in a quarry in the Backbone ridge north of Grand Tower (NE NE SE 23, 10S-4W), where it is 33 feet thick. The Howardton extends throughout much of the area of the Lingle, but it is overlapped by the Tripp Member in the northern part. It is as much as 110 feet thick in southeastern Illinois and generally



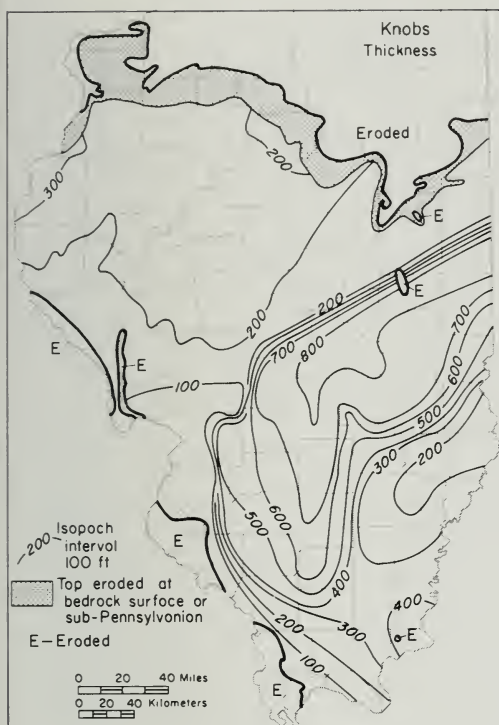


Fig. D-16—Thickness of the Knobs Megagroup.

principal reference section. Both Grimmer (1968) and North (1969) placed the type Misenheimer well above the base of the Lingle (where Savage had placed it), but Grimmer assigned the strata below the Misenheimer to the St. Laurent Formation of Missouri, whereas North subdivided them into the Howardton and Tripp Members of the Lingle. The Misenheimer occurs only in and near the outcrop region in Jackson, Union, and Alexander Counties (fig. D-15). It consists of as much as 50 feet of dark gray to gray-brown, calcareous, spore-bearing shale that contains a few macrofossils.

**Walnut Grove Limestone Member**—The Walnut Grove Limestone Member of the Lingle Formation (North, 1969, p. 29-30), the uppermost member, is named for Walnut Grove Church, Union County, 1 mile southeast of the type section, an outcrop near the head of a small tributary of Clear Creek (SE SE SW 22, 11S-2W), where the member is 29 feet thick. The Walnut Grove occurs only in and near the outcrop area in Jackson, Union, and Alexander Counties (fig. D-15), and its maximum thickness is about 50 feet. It is cherty, very silty, glauconitic, spore-bearing, fine-grained, fossiliferous limestone locally interbedded with very dark brown, calcareous shale. The Rendleman Oolite Bed near the base is a distinctive key bed. Fossils include crinoids, corals, brachiopods, and sporangites.

**Rendleman Oolite Bed**—The Rendleman Oolite Bed (North, 1969, p. 30-31) is named for Rendleman School, 1 mile east of the type section (part of the Walnut Grove type section), where it is 1.5 feet thick and occurs 4 feet above the base of the Walnut Grove Member. It is a persistent, distinctive bed. The oolites, which are poorly sorted and have a maximum diameter of 1 mm, occur in a fine-grained limestone matrix.

## Alto Formation

The Alto Formation (Savage, 1920, p. 168-178), which overlies the Lingle Formation in southwestern Illinois, is named for Alto Township, Union County, where the type section is along a creek (cen. N1/2 NE NE 34, 11S-2W). The Alto Formation is in essentially the same area as the Misenheimer and Walnut Grove Members of the Lingle Formation (fig. D-15). It is as much as 100 feet thick. The lower part consists of dolomitic and calcareous shale and siltstone; the shale resembles the Misenheimer. The upper part is silty, cherty, gray to dark gray dolomite that grades from coarsely crystalline at the top to finely crystalline at the base. White, gray, and black chert nodules are abundant. On the basis of its few macrofossils (*Devonochonetes* sp., "*Reticularia*" *laevis* and *Mucrospirifer mucronatus*), Savage assigned the Alto to the Upper Devonian, but the conodont fauna (Orr, 1964), which includes *Polygnathus cristata*, relates the Alto to the uppermost Middle Devonian (Collinson et al., 1967a). Although Savage (1920) and Workman and Gillette (1956) believed the Alto extended under the oldest part of the New Albany Shale, Weller (1940) and North (1969) interpreted both the Lingle and Alto as grading laterally into the New Albany. North correlated the Alto with the upper part of the Sweetland Creek Shale in the deep part of the Illinois Basin, but Collinson et al. (1967a) interpreted the uppermost conodont faunas of the Blocher Shale, below the Sweetland Creek, as Upper Devonian in age, in which case both the Alto and the part of the Lingle Formation above the Howardton Member are probably equivalent to the Blocher.

## KNOBS MEGAGROUP

The Knobs Megagroup (Swann and Willman, 1961, p. 480-481) consists of the Devonian and Mississippian clastic rocks that overlie the Hunton Limestone Megagroup and underlie the Mammoth Cave Limestone Megagroup throughout the Illinois Basin (fig. 14). It is named for the Knobs, an area of highly dissected Devonian and Mississippian shales that partially surrounds the Bluegrass Region and lies in front of the Highland Rim Escarpment of Kentucky and Indiana. In much of the Illinois Basin, the Knobs Megagroup includes shale, siltstone, and sandstone from the base of the Blocher Shale of the New Albany Group to the top of the Borden Siltstone; but on the flanks of the basin, where shallow-water carbonates were deposited, the stratigraphic interval is restricted at both top and bottom. The Knobs has a maximum thickness of about 1000 feet, but it is much thinner in western Illinois and it thins out in places (fig. D-16). The Knobs is mainly black shale in most of the basin, but in central Illinois it is dominated by the great volume of gray siltstone and silty shale in the Borden delta.

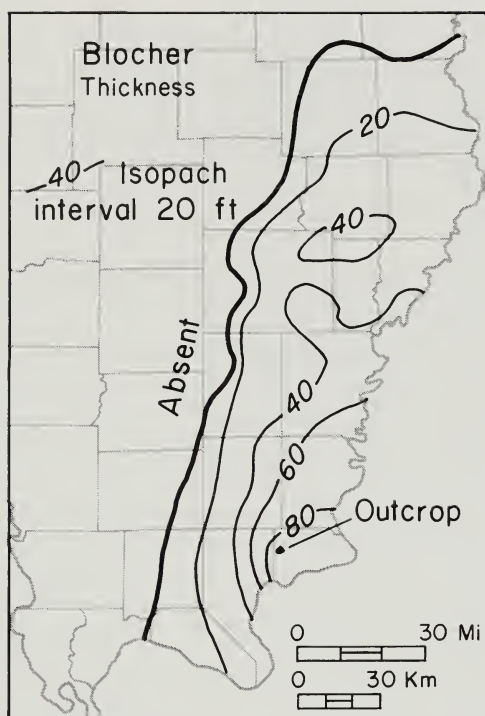


Fig. D-17—Thickness of the Blocher Shale (after North, 1969).

### New Albany Shale Group

The New Albany Shale Group (Borden, 1874, p. 158) is named for New Albany, Floyd County, Indiana, where it is largely black shale that overlies the Sellersburg Limestone (Lingle Formation in Illinois) and is overlain by the Rockford Limestone (Chouteau Limestone in Illinois). The unit, originally called the New Albany black slate, is classified as a formation in the type region (Shaver et al., 1970). It consists of the essentially continuous body of Middle and Upper Devonian and Kinderhookian (lower Mississippian) black, gray, and green shale. It includes the Blocher, Sweetland Creek, Grassy Creek, Saverton, and Hannibal Shales (figs. D-2, M-3). It has a maximum thickness of about 400 feet and is exposed in western and southern Illinois. Lineback (1968a) differentiated the New Albany in Indiana into the Blocher Member (calcareous to dolomitic, pyritic shale rich in organic matter) at the base, the Selmer Member (greenish gray mudstone), the Morgan Trail Member (black, fissile, siliceous, pyritic shale), the Camp Run Member (alternating greenish gray mudstone and black shale), and the Clegg Creek Member (black,

silty or dolomitic, pyritic shale) at the top. These units have been recognized in subsurface in eastern Illinois, but, except for the Blocher, they have not been traced widely. Black shale containing Devonian sharks' teeth has been found in crevices in the Silurian dolomite in the Chicago area (Bretz, 1939), indicating that the New Albany formerly extended across the Kankakee Arch. The name "Mountain Glen Shale," formerly used for the New Albany in southwestern Illinois (Savage, 1920; Weller, 1940), was replaced by "New Albany" (Workman and Gillette, 1956). The New Albany has now been extended to include comparable shales in western Illinois, and the term "Champ Clark Group" used by Workman and Gillette (1956) is no longer needed for the Upper Devonian formations. The New Albany, particularly the dark shale, contains an abundance of brown resinous spores, *Tasmanites*, which are called *Sporangites* in many reports. Conodonts are common, but normal marine macrofossils are scarce, except in a few limestone beds near the base and top. The New Albany is correlated with the Antrim and Ellsworth Shales of Michigan and the Chattanooga of Tennessee (Collinson et al., 1967a).

### Blocher Shale

The Blocher Shale (Campbell, 1946, p. 840; Lineback, 1968a, p. 1295-1298), the basal formation in the New Albany Group, is named for Blocher, Scott County, Indiana, and the type section is 1.5 miles southeast of Blocher on Highway 50, 1 mile east of the Baltimore and Ohio Railroad. It originally included only the lower 8-10 feet of black shale in the type area, but Lineback (1968a) extended it upward about 6 feet to the base of the *Spaethiocaris* Zone, which is a gray shale more easily traced, and that position is now accepted. The Blocher Shale extends from the type locality into eastern Illinois (Workman and Gillette, 1956), where it is as much as 80 feet thick, but it thins out in the central part of the state (fig. D-17). North (1969) correlated it with the Tripp Member of the Lingle Formation, but the conodont fauna suggests that it is equivalent also to higher parts of the Lingle, the Alto Formation, and the earliest Upper Devonian strata (Collinson et al., 1967a).

### UPPER DEVONIAN SERIES

The term "Upper Devonian Series" has been in general use in Illinois since 1925 (Bassett), prior to which the New York terms "Senecan" and "Chautauquan" had been used in addition to Upper Devonian (figs. D-4, D-5). Upper Devonian sediments underlie

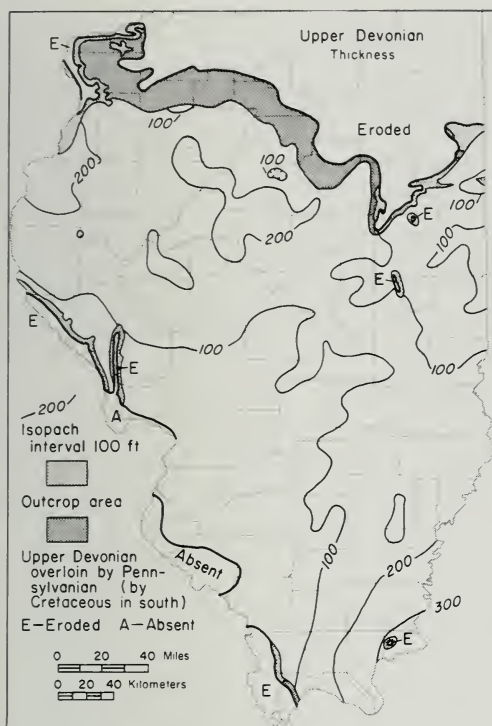


Fig. D-18—Thickness of the Upper Devonian Series.

most of southern and western Illinois. They completely overlap the then subsiding Sangamon Arch, on which Middle Devonian sediments had not been deposited (fig. D-18). They are more than 300 feet thick in Hardin County and as much as 275 feet thick in Mercer County, but elsewhere they are generally less than 200 feet.

In the Devonian type region in England, Upper Devonian applies to the Frasnian (lower) and Famennian (upper) Stages. Conodont studies by Collinson (1967) placed the base of the Frasnian at the base of the Sylamore Sandstone in central and western Illinois, at the top of the Alto Formation in southwestern Illinois, and a few feet below the top of the Blocher Shale in southeastern Illinois. Savage (1920) included the Alto and younger Devonian rocks in the Upper Devonian, as did Weller (1940), Cooper et al. (1942), Cooper (1944), and Orr (1964). However, Weller (1944b), on sedimentational evidence, and Collinson et al. (1967a), on the basis of conodont faunas, tentatively placed the Alto in the Middle Devonian, which is the current practice. The position of the top of the Upper Devonian Series was long debated, as described under the discussion of the Devoni-

an System, but the top of the Louisiana Limestone (or a few feet above it in the Hannibal Shale) in western Illinois, the top of the Grassy Creek Shale in southwestern Illinois, and a position near the top of the New Albany Group in eastern Illinois are now generally accepted as the top of the Upper Devonian.

In the major part of the Illinois Basin the Upper Devonian Series consists largely of the black and gray shale of the New Albany Group, but on the flanks of the Ozark Uplift and on the Mississippi River Arch it also includes limestone, sandstone, and siltstone (fig. D-19). The Louisiana Limestone contains a large variety of macrofossils (Williams, 1943), but the shales generally contain few. Zonation in the series, therefore, is based largely on the conodonts, which, along with abundant *Tasmanites*, are common in the shale formations.

The Upper Devonian rocks are generally conformable on the Middle Devonian strata, but in western and southwestern Illinois a minor unconformity occurs at the base of the Sylamore Sandstone, of the Sweetland Creek Shale, or of the Grassy Creek Shale.

### Sylamore Sandstone

The Sylamore Sandstone (Penrose, 1891b, p. 113, 114), the basal Upper Devonian formation in central and western Illinois (Workman and Gillette, 1956), is named for Sylamore Creek, Stone County, central northern Arkansas. It is widely but sporadically present in Illinois, is rarely more than 5 feet thick, and generally varies from a few inches to a mere thin layer of sand embedded in the base of the Sweetland Creek Shale or the Grassy Creek

GR	FORMATION		FEET
New Albany	Louisiana Ls.		0-40
	Saverton Sh.		5-110
	Grassy Creek Sh.		0-225
	Sweetland Creek Sh.		0-200
	Sylamore Ss.		0-5

Fig. D-19—Columnar section of the Upper Devonian Series.

Shale. It consists of well rounded, fine to medium, quartz sand grains, like those in the older Paleozoic sandstones. It varies from friable sandstone to grains cemented with pyrite, calcite, or dolomite. In the western part of Illinois, it rests unconformably on the Middle Devonian Cedar Valley Formation or Wapsipinicon Limestone, on Silurian dolomite, or locally on Ordovician limestone. In eastern Illinois it probably is equivalent to thin sandy beds in the upper part of the Blocher Shale and the lower part of the Sweetland Creek Shale. It is more or less continuous through Missouri, north and west of the Ozark Uplift, to the type locality, and it is correlated with the Hardin Sandstone east of the Ozarks in Kentucky and Tennessee.

### Sweetland Creek Shale

The Sweetland Creek Shale (Udden, 1899, p. 65-78; Collinson et al., 1967a, p. 960-961) is named for Sweetland Creek, Muscatine County, Iowa, and the type section is an exposure along that creek, 4 miles northeast of Muscatine (cen. N $1\frac{1}{2}$  27, 77N-1W), where it is 14 feet thick and is overlain by 6 feet of Grassy Creek Shale. As originally defined, the Sweetland Creek included all the Devonian shale at the type locality. It therefore was essentially equivalent to Grassy Creek Shale (Workman and Gillette, 1956). As now defined (Collinson et al., 1967a), the Sweetland Creek Shale is restricted to the dominantly gray and green shale that underlies the black Grassy Creek and extends throughout much of the Illinois Basin (Collinson, 1961; North, 1969). The Sweetland Creek Shale is only a few inches thick in southwestern Illinois, but reaches 50 feet thick in northwestern Illinois and 200 feet in southeastern Illinois, where it appears to be essentially continuous with the Selmier Member of the New Albany Shale in Indiana. Although dominantly gray in the western part of Illinois, the Sweetland Creek contains some dark gray to black beds. In the central and eastern parts of Illinois, it is generally dark and not readily separated in well samples from the Blocher Shale below and the Grassy Creek Shale above. However, in that area it is easily identified on geophysical logs, which show persistent variations that permit key beds to be widely traced within the formation (North, 1969). Macrofossils are scarce, but the conodonts have been studied in considerable detail and indicate ages ranging from early to middle Upper Devonian (Klapper and Furnish, 1962; Collinson et al., 1962).

### Grassy Creek Shale

The Grassy Creek Shale (Keyes, 1898, p. 59-63; 1912, p. 149; Collinson et al., 1967a, p. 961) is named for Grassy Creek, a stream in Pike County, Missouri. It originally included all the black, gray, and green shale below the Louisiana Limestone and above the Cedar Valley or older formations, but in 1912 Keyes differentiated the upper gray shale as the Saverton Shale, and Collinson et al. (1967a) restricted the Grassy Creek further by assigning the lower gray and green shale to the Sweetland Creek Shale. No type section was designated and some of the sections referred to by Keyes include Maquoketa Shale (Weller, 1936). Mehl (1960) named a section in the Mississippi bluffs several hundred feet north of the Champ Clark Bridge at Louisiana, Pike County, Missouri, as the

type locality (SW NW NE 18, 54N-1W). In Illinois the Grassy Creek was at first restricted to the western part of the state, but in 1956 Workman and Gillette extended it to central and southwestern Illinois in place of the Mountain Glen Shale, a name long used in that area (Savage, 1920; Weller, 1940). Still later it was extended to eastern Illinois (Collinson et al., 1967a; North, 1969). The Grassy Creek occurs in nearly all the area in which Upper Devonian strata appear. It is well exposed in Pike, Calhoun, and Jersey Counties in western Illinois and in Union County and locally in Hardin County in southern Illinois (fig. D-18). In subsurface its high resistivity on electric logs serves to differentiate it from the Saverton Shale above and from the Sweetland Creek Shale below.

### Saverton Shale

The Saverton Shale (Keyes, 1912, p. 149), a gray shale overlying the black Grassy Creek Shale and underlying the Louisiana Limestone, is named for Saverton, Ralls County, Missouri. No type section was designated by Keyes, but Mehl (1960) named an exposure in the Mississippi River bluff at Louisiana, Pike County, Missouri, as the type section, the same exposure named as the type for the Grassy Creek Shale. Because the Louisiana Limestone is limited to a small area in Illinois (fig. D-20), the Saverton is more commonly overlain by the Mississippian "Glen Park" or Hannibal Formations. The Saverton is well exposed in western Illinois in and near the Mississippi and Illinois River bluffs in Pike, Calhoun, and Jersey Counties. It is 5-110 feet thick in western Illinois, but is generally less than 10 feet thick where overlain by the Louisiana Limestone. In eastern and southern Illinois, it is commonly not differentiated and is included in the Hannibal Formation. The Saverton is a bluish to greenish gray, silty shale that contains both thin sandy beds and calcareous beds and grades to calcareous siltstone in the upper part. It grades into the overlying Louisiana Limestone, the lower part of which in places grades laterally into the uppermost Saverton. The few macrofossils present in the Saverton include *Spirifer marionensis* and *Orbinaria puxidata*. Conodonts are abundant, especially in the siltstone at the top, and *Palmatolepis minuta*, *P. gracilis*, *P. glabra*, and *P. quadrinodosa marginifera* indicate an Upper Devonian age (Scott and Collinson, 1961; Collinson et al., 1967a).

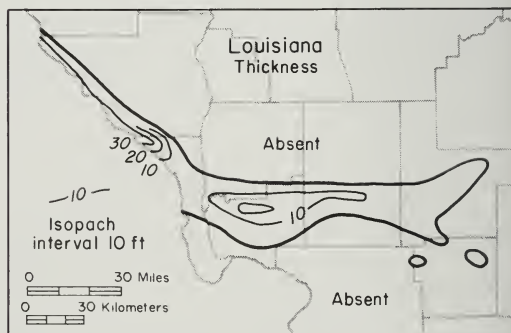


Fig. D-20—Thickness of the Louisiana Limestone.

## Louisiana Limestone

The Louisiana Limestone (Keyes, 1892, p. 289) is named for Louisiana, Pike County, Missouri, where it is well exposed in the Mississippi River bluffs. No type section was designated, but a prominent exposure on the south side of Louisiana, where it is underlain by the Saverton Shale and overlain by the Hannibal Shale, is commonly accepted as the type section. The Louisiana occurs in an area 10-25 miles wide extending eastward from the Mississippi River into west-central Illinois (fig. D-20). It is a lenticular body as much as 40 feet, but more commonly 10-20 feet thick. It is exposed along the Mississippi and Illinois Valleys in Pike, Calhoun, and Jersey Counties. The formation is light gray to buff, lithographic limestone with thin shale partings and dolomite interbeds. The limestone is very pure and is probably a chemical precipitate. It contains a large variety of macrofossils

dominated by small brachiopods, particularly *Schuchertella*, *Chonetes*, *Cyrtina*, and *Ambocoelia*, but microcrinoids, bryozoans, and ostracodes also are common (Williams, 1943). The Devonian or Mississippian age of the Louisiana Limestone and its relation to the similar McCraney Limestone, which is exposed in Illinois essentially within sight of the type Louisiana in Missouri, were major controversies for many years (Collinson, 1961; Scott and Collinson, 1961). Studies of the conodont faunas demonstrated that the Louisiana was of Upper Devonian age and the McCraney was of Mississippian age, resolving both problems and substantiating field tracing of the units in the Mississippi River bluffs in Illinois. The Louisiana is unconformably overlain by the "Glen Park" Formation, but, as the faunas indicate only a short interruption in sedimentation, the unconformity appears to be related to minor uplift on the flank of the Lincoln Anticline.

## MISSISSIPPIAN SYSTEM

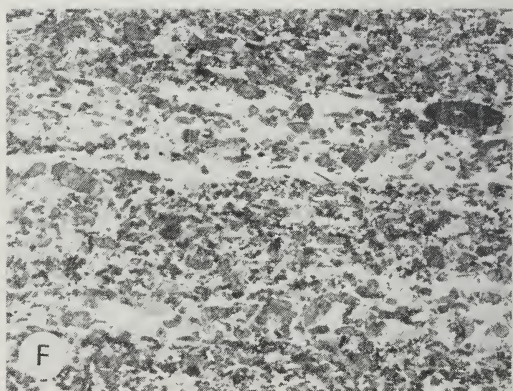
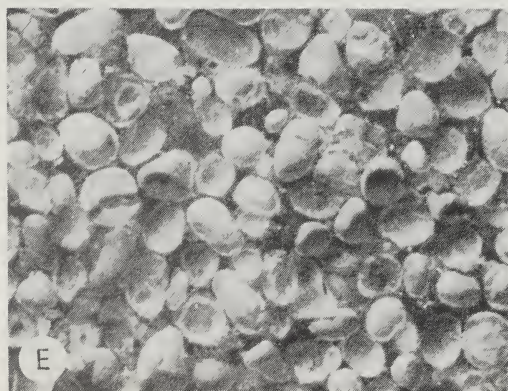
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and Jerry A. Lineback*

The Mississippian System (Winchell, 1869; Williams, 1891), which overlies the Devonian System and underlies the Pennsylvanian System, is named from exposures in the bluffs of the Mississippi River in Iowa, Illinois, and Missouri (fig. M-1). In earlier reports these strata were called "Carboniferous limestone," or "Lower Carboniferous" (Worthen, 1866) to differentiate them from the upper Carboniferous or "Coal Measures," that are now called the Pennsylvanian System. "Carboniferous" continues to be used in other countries, and the U.S. Geological Survey recognizes the Mississippian and Pennsylvanian Systems as the Carboniferous Systems (Keroher, 1970).

The Mississippian System is well developed in the Illinois Basin east of the type exposures, and it covers most of Illinois south of a line running roughly from Monmouth, Warren County, to Hoopston, Vermilion County (fig. M-2). It crops out in a belt around the western and southern rim of the Illinois Basin from Henderson County on the west through Hardin County on the southeast, but on the north side of the basin it is overlapped by Pennsylvanian strata and does not crop out. In northeastern Illinois it is at the top of the bedrock but is covered by glacial drift. The system is over 3200 feet thick in southern Illi-

nois but thins northward because of truncation and because of depositional thinning of many of its component formations (fig. M-3).

Although limestone is the dominant rock type in the Mississippian System, a large siltstone delta is present in central and eastern Illinois, and shale and sandstone formations are prominent in parts of the system. The lowest part of the system consists mainly of shale and siltstone and is included in the upper part of the Knobs Megagroup (fig. 14). Limestone, which makes up most of the middle part of the system, is referred to the Mammoth Cave Limestone Megagroup. The alternating limestone-shale and sandstone-shale formations of the upper part compose the Pope Megagroup. Three major varieties of limestone occur in the system—(1) very fine-grained or lithographic, dense, medium-gray, mostly cherty limestone; (2) medium- to coarse-grained, light gray, crinoidal or bryozoan limestone, part of it very cherty; and (3) medium- to coarse-grained, light gray to white, oolitic limestone. The shales are mainly dark greenish gray, but thin beds of red and green shale are extensive. The sandstones are very fine to fine grained and light gray or light greenish gray. The siltstones are light greenish gray.



Much of the limestone and shale is exceedingly fossiliferous (fig. M-4). Brachiopods are particularly numerous, with spiriferids and productids most abundant. The Burlington Limestone, and, to a lesser extent, the Keokuk Limestone consist mainly of crinoidal debris and are zoned on the basis of crinoid genera and species. Fenestrate bryozoan debris, mostly of *Archimedes*, is abundant in some beds in the Warsaw, Salem, and Ullin Formations. Blastoids, particularly pentremiids, are characteristic of some limestone units in the Chesterian Series, as are *Schizoblastus* and *Metablastus* in the Valmeyeran and *Orophocrinus* and *Globocrinus* in the Kinderhookian. Shark teeth are common in some beds of the Burlington and Keokuk Limestones, and Foraminifera, particularly endothyrids, are abundant in the Salem Limestone. Conodonts are common to abundant throughout the Mississippian and provide a basis for biostratigraphic zonation (Collinson et al., 1962). Thin beds of coal occur in the Chesterian (late Mississippian) sandstones, and the megaspores in the coals indicate dominance of a lepidocarp-lepidodendrid flora (Winslow, 1959).

Three series, all with type localities in Illinois, are differentiated at time planes established by differences in faunas. The Kinderhookian Series, at the base, is dominantly shale and is relatively thin. The Valmeyeran, in the middle, is relatively thick and is dominantly limestone and siltstone. The Chesterian, at the top, is also thick and consists of alternations of limestone-shale and sandstone-shale formations.

The main sources of the siliceous clastic sediments in the Mississippian System appear to have been northeast of Illinois, although some sediment came from the northwest and minor quantities from the Ozark region. The delta represented by the Borden Siltstone grew southeastward into the Illinois Basin. The Chesterian sands were carried into the basin by the Michigan River, which also came from the northeast (fig. M-31). The sands are moderately angular and lack the high degree of rounding characteristic of older sandstones,

which were probably beneath the seas or buried by younger formations during Mississippian time.

The boundary between the Devonian and Mississippian Systems occurs in the New Albany Shale Group. Its exact position has long been controversial, but it is now widely accepted, on the basis of conodont evolution, as probably occurring near the base of the Hannibal Shale, above the Louisiana Limestone, and probably in or below the highly variable "Glen Park" Formation (Collinson et al., 1971). The Louisiana Limestone is present in only a small area, and the Devonian-Mississippian boundary commonly occurs within the shale sequence. The contact is generally conformable, but in western Illinois a minor unconformity marks the contact of the "Glen Park" Formation on the Louisiana Limestone.

The contact between the Mississippian and Pennsylvanian Systems is one of the major unconformities in Illinois and is the boundary between the Absaroka Sequence and the Kaskaskia Sequence (fig. 14). Strata in the Illinois Basin were warped, faulted, and truncated by erosion at the close of the Mississippian Period. Valleys as much as 450 feet deep were cut into Chesterian strata and subsequently were filled with Pennsylvanian sediments (Bristol and Howard, 1971). The Pennsylvanian rocks progressively overlap older Mississippian formations northward and westward from the southern part of the Illinois Basin. Around the margin of the basin the Pennsylvanian rocks overlap older systems.

## KINDERHOOKIAN SERIES

The Kinderhookian Series (Meek and Worthen, 1861b, p. 288; Collinson, 1961, p. 102) is named for the village of Kinderhook, northwestern Pike County, where the type section consists of exposures in the Mississippi River bluffs. There Kinderhookian strata overlie the Devonian Saverton Shale, and the McCraney Limestone is at the top of the section. The younger Kinderhookian strata, which lie be-

Fig. M-1—Exposures and textures of Mississippian rocks.

- A—Vienna Limestone overlying the sheet facies of the Tar Springs Sandstone in roadcut (about 40 feet high) of Illinois Highway 3 on southeast side of Chester, Randolph County.
- B—Massive Ste. Genevieve Limestone overlying well bedded St. Louis Limestone in Mississippi River bluff (about 60 feet high) on northwest side of Alton, Madison County.
- C—Kinkaid Limestone showing clay-filled solution cavity in the Goreville Member at the top overlying a layer of shale with a red bed (black) at the top of the Cave Hill Member; in Southern Illinois Limestone Company quarry north of Buncombe, Johnson County.
- D—Well bedded St. Louis Limestone with a cave in its base overlying massive Salem Limestone in Mississippi River bluff a mile northwest of Prairie du Rocher, Randolph County.
- E—Oolitic texture of the Ste. Genevieve Limestone at Anna, Union County ( $\times 10$ ).
- F—Granular texture of the Ullin Limestone along Mill Creek, south of Anna, Union County ( $\times 1$ ).

tween the Burlington Limestone (above) and the McCraney (below), are exposed near by (Collinson, 1961). The Kinderhookian extends throughout most of western, central, and

southern Illinois (fig. M-5) but is well exposed only along the Mississippi and Illinois Valleys in western Illinois. Small exposures occur around Hicks Dome in Hardin County

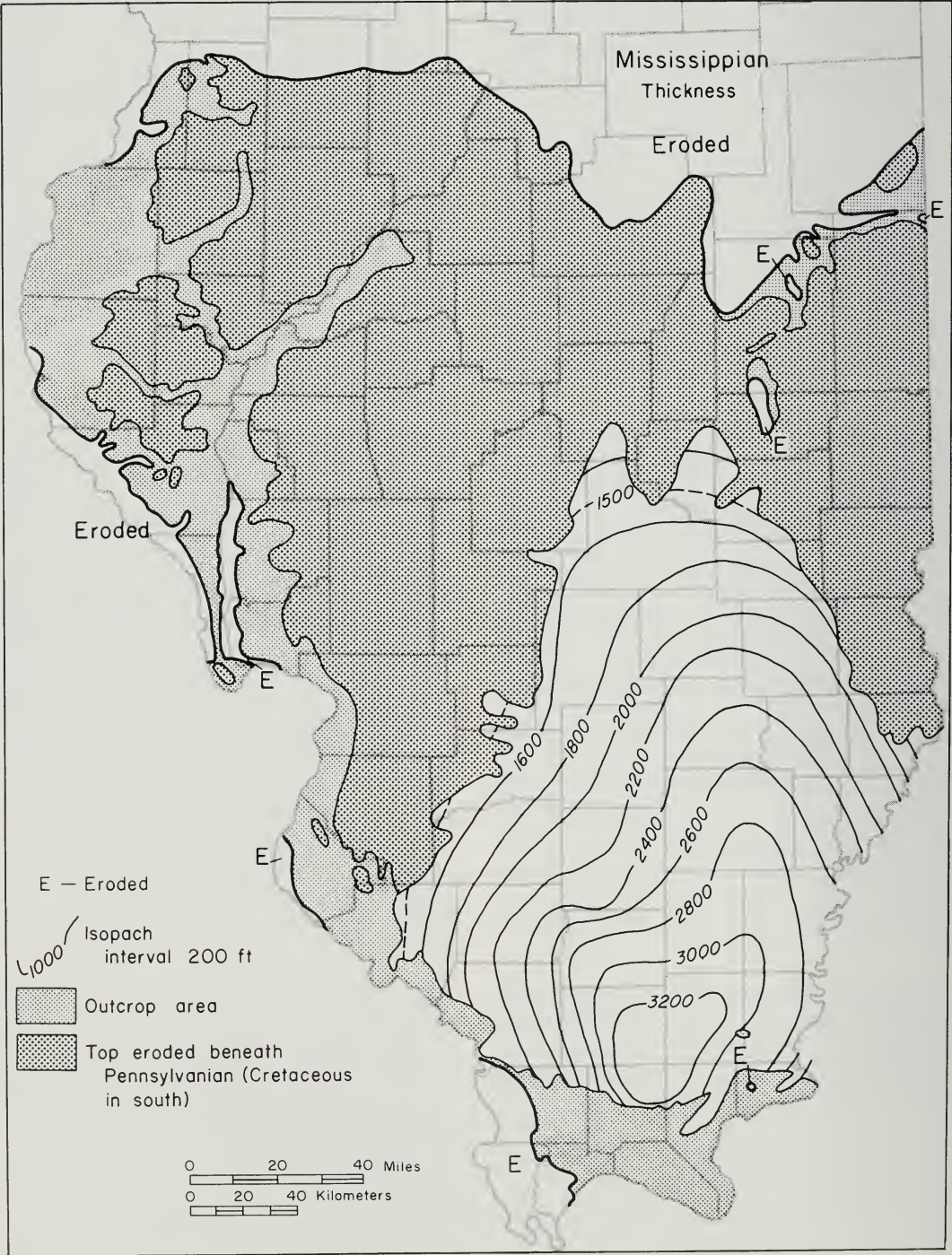


Fig. M-2—Areal extent of the Mississippian System in Illinois. Thickness is shown where upper Chesterian strata are present.

and at Horseshoe in Saline County (N1/2 36, 9S-7E). Elsewhere along its boundary, it is overlapped by younger Mississippian or Pennsylvanian strata.

The Kinderhookian is as much as 167 feet thick in western Illinois, where the North Hill Group (fig. M-6) is well developed, and 100 to 120 feet thick in a belt running east from Calhoun County where the "Glen Park" is well developed. It is thin in the eastern and southern parts of the Illinois Basin. The Kinderhookian Series is dominantly shale but has a thin, extensive limestone at the top and a limestone-siltstone-shale formation locally developed at the base.

As originally defined (fig. M-7), the Kinderhook Group included all the strata between the black shale (Grassy Creek) and the Burlington Limestone, strata previously correlated with the Devonian Chemung Group of New York. Later, the black shale was also included in the Kinderhook Group, which was assigned to the Mississippian System. After the Kinderhookian was made a series, the position of the Mississippian-Devonian boundary became controversial (Stainbrook, 1935; Weller, 1939). Studies of the conodont faunas resulted in a redefinition of the Kinderhookian Series to include only those strata overlying the Louisiana Limestone and underlying the Meppen Limestone, or the Burlington where the Meppen is absent (Collinson, 1961). As thus defined, the Kinderhookian Series includes the upper part of the New Albany Group, the widespread Chouteau Limestone, and, in a small area in western Illinois, the North Hill Group.

The Kinderhookian Series is generally conformable with the Upper Devonian Series (below) and the Valmeyeran Series (above), but in western Illinois both contacts are marked by local unconformities that resulted from minor uplifts on the flanks of the Ozarks.

### "Glen Park" Formation

The "Glen Park" Formation (Ulrich, 1904, p. 110; Moore, 1928, p. 138-140) is named for Glen Park Sta-

SERIES	STAGE	SEQ.	MEG.	G-WEST	G-EAST	FORMATION	MEMBER
CHESTERIAN	ELVIRAN		Pope			Grave Church Sh.	
						Kinkaid Ls.	Gareville Ls. Cave Hill Sh. Negli Creek Ls.
						Degania Ss.	
						Clare	Ford Station Ls. Tygett Ss. Cora Ls.
						Palestine Ss.	
						Menard Ls.	Allard Ls. Scattsburg Ls. Walche Ls.
						Waltersburg	
						Vienna Ls.	
						Tar Springs Ss.	
						Glen Dean Ls.	
GASPERIAN	HOM- BERGIAN		Pope	Okaw	Gai- conda	Hardinsburg Ss.	
						Honey Ls.	
						Fraileys Sh.	Big Clifty Ss.
						Beech Creek Ls.	
						Cypress Ss.	
						Ridenhower	Reelsville Ls. Sample Ss. Beaver Bend Ls.
						Bethel Ss.	
						Dawneys Bluff Ls.	
						Yankeetown Ss.	
						Renault Ls.	Shetlerville Papcorn Ss. B. Levias Ls.
GENEVIEVERAN		Kaskaskia (WEST) (EAST)	Mammoth Cave	Paint Creek	Cedar Bluff	Aux Vases Ss.	Rasiclare Ss.
						Ste. Genevieve Ls.	Jappa Karnak Ls. Spar Mtn. Ss. Fredania Ls.
						St. Louis Ls.	
						Salem Ls.	Racher Chalfin Fults Kidd
						Ullin Ls.	Harradsburg Ls. Ramp Creek Ls.
						NORTH and WEST	
						FORMATION	MEMBER
						Sanara	
						Warsaw Sh.	
						Keokuk Ls.	Mantrase Chert
VALMEYERAN		(WEST) (EAST)				Burlington Ls.	
						Fern Glen	
						Meppen Ls.	
						Starrs Cave Ls.	
						Prospect Hill Sts.	
						McCrane Ls.	
						Hannibal Sh.	Nutwood Sh.
						"Glen Park"	
						SOUTH and EAST	
						FORMATION	FORMATION
KINDERHOOKIAN						Fort Payne	
						Borden Sts. Bilyeu M.	Springville Sh. State Pand M.
						Chouteau Ls.	
						Hannibal Sh.	

Fig. M-3—Classification of the Mississippian System.

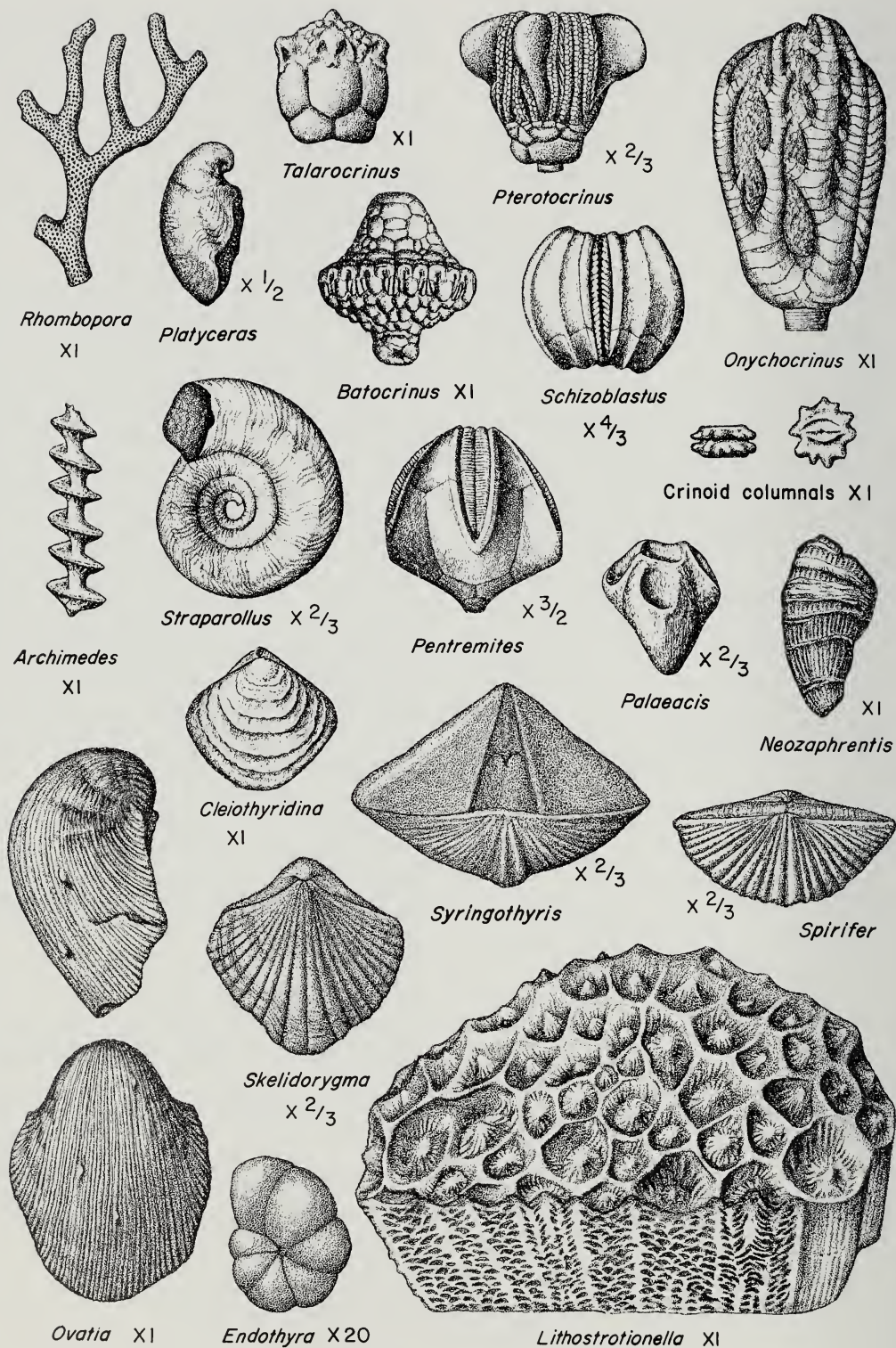


Fig. M-4—Typical Mississippian fossils.

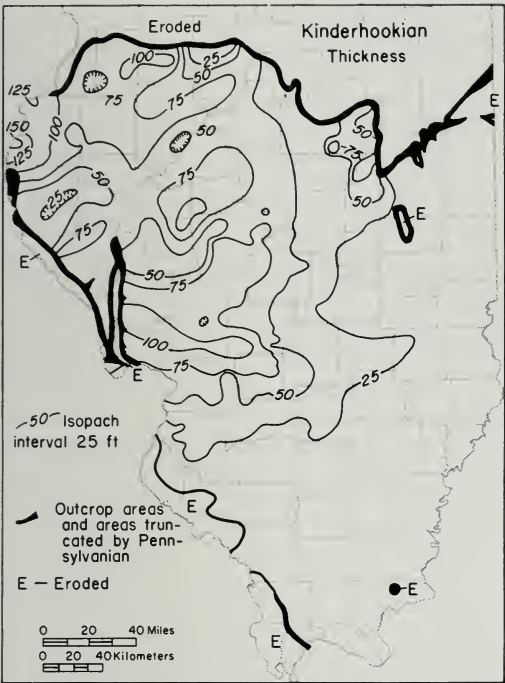


Fig. M-5—Thickness of the Kinderhookian Series.

tion, about 25 miles south of St. Louis, Jefferson County, Missouri, where 1.4 feet of fossiliferous oolitic limestone was named Glen Park. Stuart Weller (1914, p. 464-467) gave the name "Hamburg Oolite" to exposures of the oolitic limestone at Hamburg that he considered to be younger than the type Glen Park, but the name was preempted and Moore (1928) redefined the name "Glen Park" to include the strata at Hamburg. However, studies of the conodonts indicate that the two units are not of the same age—the type Glen Park being Devonian and the Hamburg strata Mississippian—but the name "Glen Park" has been retained pending introduction of a new name.

The "Glen Park" is exposed in and near the Mississippi River bluffs in Calhoun, Pike, and Jersey Counties, and in the lower Illinois Valley in Calhoun and Jersey Counties. It is restricted to western Illinois where its thickness varies greatly but does not exceed 25 feet in the outcrop area. Much of the thick brown shale included in the "Glen Park" by Workman and Gillette (1956) is now included in the Hannibal Shale. The lithology of the "Glen Park" varies considerably and may be almost any combination of sandy, silty, brown or buff limestone, buff siltstone, silty shale, oolitic limestone, limestone conglomerate, or thin sandstone beds. In Gresham Hollow, about a mile southeast of Hamburg, Calhoun County (NW 1, 10S-3W), it consists of calcareous, blue-gray siltstone overlying light gray to buff, silty, dense, fine-grained limestone. The limestone contains beds of dolomitic siltstone bearing *Tasmanites* and also lenses of highly fossiliferous, white to buff, conglomeratic, oolitic, cross-bedded limestone. Stuart Weller (1906b) described the fauna. The "Glen Park" rests with apparent erosional contact on the Louisiana Limestone, or on the Saverton

Shale where the Louisiana is not present. However, no unconformity is generally recognizable where the "Glen Park" is absent.

Hannibal Shale

The Hannibal Shale (Keyes, 1892, p. 289) is named for Hannibal, Missouri, where about 75 feet of sandy shale between the Louisiana Limestone (below) and the Burlington Limestone (above) was included in the forma-

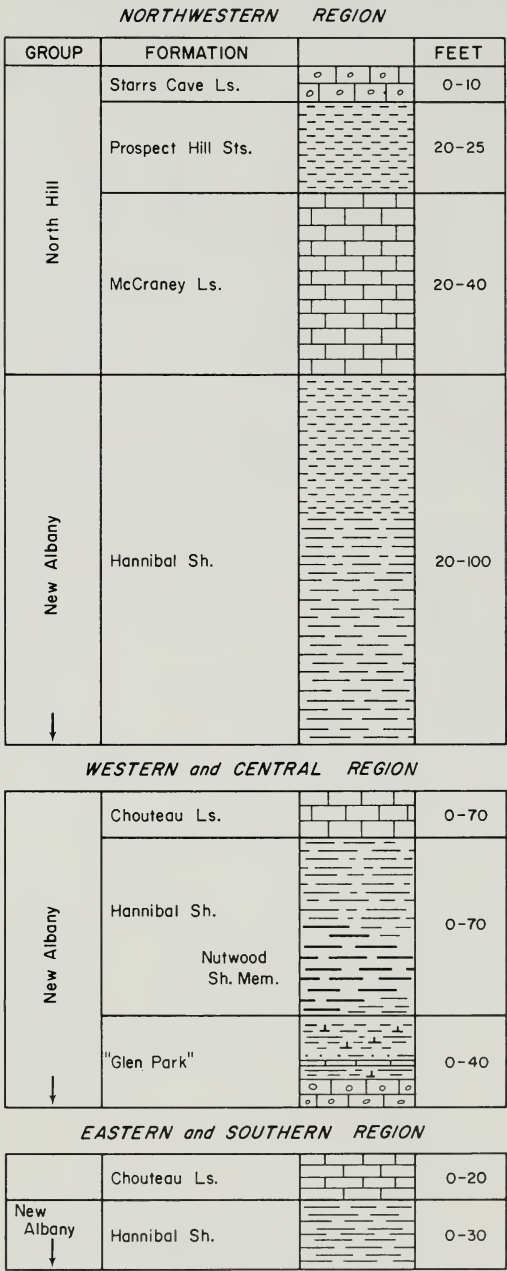


Fig. M-6—Columnar section of the Kinderhookian Series.



or early Chesterian age at the base of the Pope Megagroup. It is named for Mammoth Cave, Kentucky. The name was introduced, first as a formation name and later as a series name, for the relatively pure limestone in the interval from the base of the St. Louis Limestone to the base of the Big Clifty Sandstone. The Mammoth Cave is entirely Mississippian in age, but both upper and lower contacts are time-transgressive and are marked by a series of step-like, vertical cut-offs (figs. 14, M-3). It occurs throughout the area of Mississippian rocks in Illinois, but it thins from nearly 2000 feet in extreme southern Illinois to little more than 100 feet in east-central Illinois (fig. M-8). It crops out extensively along the Mississippi and Illinois Valleys in western Illinois and along the Mississippi and Ohio Valleys in southern Illinois.

### Chouteau Limestone

The Chouteau Limestone (Swallow, 1855, p. 101), the uppermost formation in the Kinderhookian Series, is named for Chouteau Springs, Cooper County, Missouri, where the name was applied to 70 feet of limestone between the "Encrinital Limestone" (Burlington) and the "Vermicular Sandstone" (Hannibal). The name "Rockford," which was applied to the formation in Indiana, was used in southeastern Illinois until the older name, Chouteau, was accepted for all of Illinois (Buschbach, 1952). The Chouteau extends over almost all of Illinois south of a line from Calhoun County to northern Vermilion County (fig. M-9), but it is exposed only in Calhoun and Jersey Counties (Buschbach, 1952; Rubey, 1952; Collinson et al., 1954) and in a small area around Hicks Dome in Hardin County (Weller et al., 1952). It is well exposed in Pere Marquette State Park, southwestern Jersey County, and in the Meppen North Section, Calhoun County (SW NE 23, 12S-2W), where it is about 60 feet thick (Collinson, 1957, 1969). The Chouteau is generally less than 20 feet thick, but it thickens to nearly 80 feet in southern Calhoun County. The Chouteau consists of irregular beds of light brownish or greenish gray, lithographic to very fine-grained limestone with wavy bedding planes. The beds vary from a few inches to nearly 1 foot thick. Locally it is fine-grained dolomite. In a narrow belt extending northeastward from the Ozark region it is red or pink. Gray and buff chert nodules are present and locally abundant where the formation is more than 30 feet thick, but where it is less than 20 feet thick chert is absent. Geodes 1-8 inches in diameter and filled with calcite are common. Macrofossils also are common and conodonts are present in nearly all beds (Collinson, 1961). The Chouteau Limestone normally overlies the Hannibal Formation with apparent conformity, and in places the lower part grades laterally into the upper part of the Hannibal Shale, but in southwestern Illinois the Chouteau locally overlaps the Hannibal and lies unconformably on Devonian to Ordovician formations. In central and eastern Illinois the Chouteau is overlain by the Borden Siltstone, in western Illinois by the Burlington

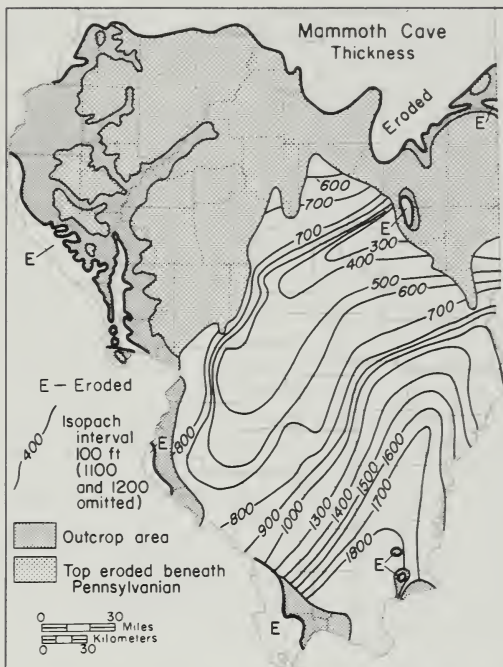


Fig. M-8—Thickness of the Mammoth Cave Limestone Megagroup. Thickness is shown where Chesterian strata are present.

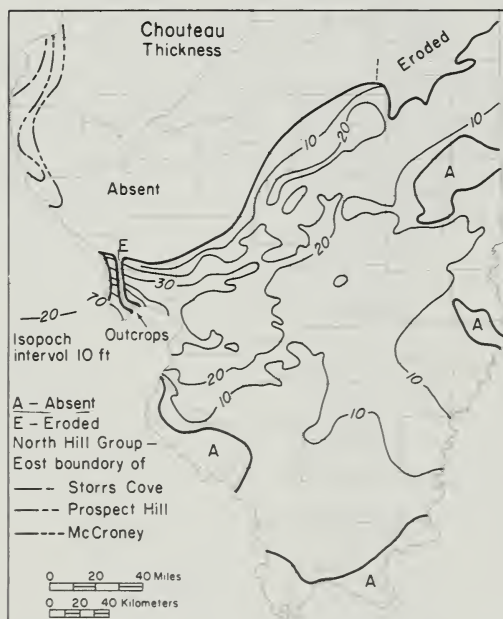


Fig. M-9—Thickness of the Chouteau Limestone and areal extent of the formations of the North Hill Group (after Buschbach, 1952; Workman and Gillette, 1956).

Limestone, in southwestern Illinois by the Meppen or Fern Glen Formations, and in Union County and vicinity by the Springville Shale (Buschbach, 1952).

North Hill Group

The North Hill Group (Laudon, 1931, p. 344) is named for the North Hill area of Burlington, Iowa. The name was introduced for the oldest member of the Hampton Formation, but Laudon later (1935) made the unit a formation. Workman and Gillette (1956) made it a group to include the McCraney Limestone at the base, the Prospect Hill Siltstone, and the Starrs Cave Limestone. These formations, extensive in Iowa, are confined in Illinois to a narrow belt east of the Mississippi River in extreme western Illinois (fig. M-9), where they have a maximum thickness of about 110 feet. The group is conformable on the Hannibal Shale but is overlain unconformably by the Burlington Limestone. Conodonts and other fossils indicate that the North Hill Group correlates with the Chouteau Limestone (Collinson, 1961).

McCraney Limestone

The McCraney Limestone (Moore, 1928, p. 20) is named for McCraney Creek (misspelled McKerney in the

original publication), near which the limestone crops out in the Mississippi River bluffs north of Kinderhook, northwestern Pike County. It was originally designated a member of the Hannibal Formation, but Workman and Gillette (1956) made it the basal formation in the North Hill Group. The McCraney occurs only in extreme western Illinois (fig. M-9). It has a maximum thickness of 58 feet near the Mississippi River but thins eastward, and within 15-20 miles it is entirely absent. It is well exposed along Fall Creek, southern Adams County (SE 23, 3S-8W). The McCraney Limestone consists of alternating thin layers of light gray to buff lithographic limestone with buff to brown, very fine-grained dolomite. A bed of coarsely oolitic limestone forms the top of the McCraney where the formation is thick. The McCraney is conformable with the underlying Hannibal and the overlying Prospect Hill, but where the latter is absent the McCraney is unconformably overlain, and in places completely truncated, by the Burlington Limestone. The conodont fauna shows that the McCraney correlates with the lower part of the Chouteau and the upper part of the Hannibal (Collinson, 1961; Scott and Collinson, 1961).

Prospect Hill Siltstone

The Prospect Hill Siltstone (Moore, 1928, p. 20; Workman and Gillette, 1956, p. 30), named for Prospect Hill, near Burlington, Iowa, was originally designated a member of the Hannibal Formation, but Workman and Gillette (1956) differentiated the uppermost beds as the Starrs Cave Formation and made the Prospect Hill a formation in the North Hill Group. It occurs in extreme western Illinois within the area underlain by the McCraney Limestone (fig. M-9). It has a maximum thickness of 29 feet but thins eastward to its boundary. It is exposed above the McCraney along Fall Creek in southern Adams County (SE 23, 3S-8W). The siltstone is light gray to buff, calcareous, pyritic, massive, and friable. It is con-

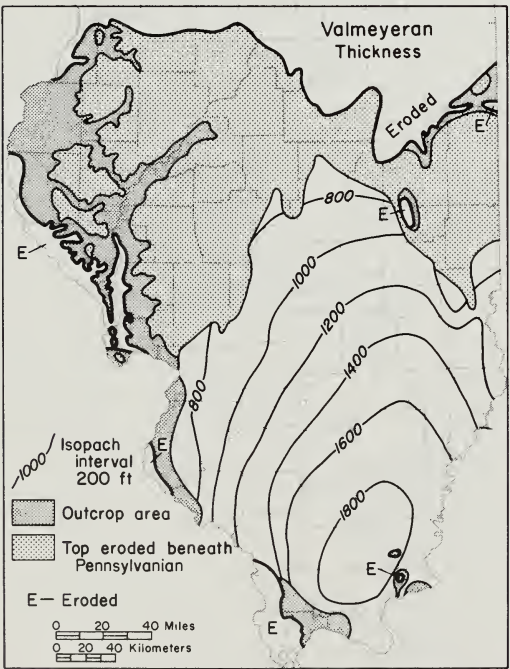


Fig. M-10—Thickness of the Valmeyeran Series. Thickness is shown where Chesterian strata are present.

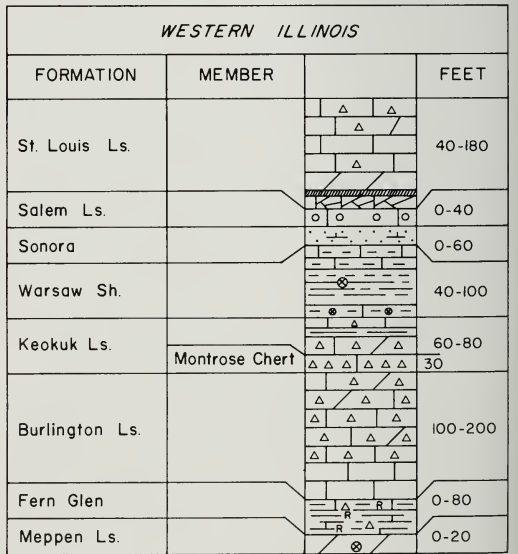

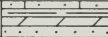
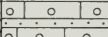
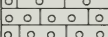
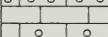
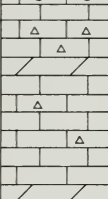
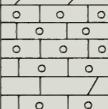

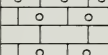
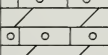
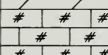
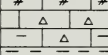
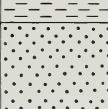
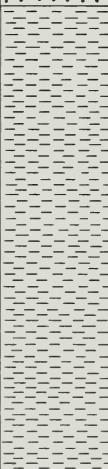


Fig. M-11—Columnar section of the Valmeyeran Series in western Illinois.

CENTRAL ILLINOIS			
FORMATION	MEMBER		FEET
Aux Vases Ss.	Rosiclare Ss.		35-45
Ste. Genevieve Ls. 180'-300'	Jappa		30-60
	Karnak Ls.		20-30
	Spar Mt. Ss.		0-40
	Fredonia Ls.		110-160
St. Louis Ls.			180-400
Salem Ls.	Rocher 10'-70'*		350-400
	Chalfin 25'-60'*		
	Fults 25'-35'*		
	Kidd 0-22'*		
Ullin Ls. 90'-150'	Harrodsburg Ls.		60-100
	Ramp Creek Ls.		30-50
Barden Sts.	Bilyeu 0-150'		100-650
			

\* Thickness in Monroe County

Fig. M-12—Columnar section of the Valmeyeran Series in central Illinois.


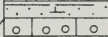
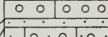
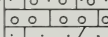
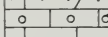
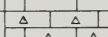
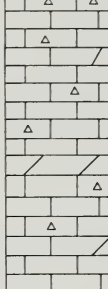
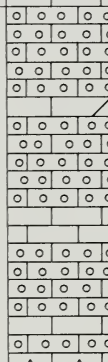
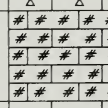
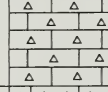


SOUTHERN ILLINOIS			
FORMATION	MEMBER		FEET
Renault <sup>†</sup> Ls.	Levias Ls.		0-10
Aux Vases Ss.	Rosiclare Ss.		20-40
Ste. Genevieve Ls. 100'-200'	Jappa		20-40
	Karnak Ls.		30-40
	Spar Mt. Ss.		5-10
	Fredonia Ls.		120-140
St. Louis Ls.			300-500
Salem Ls.			100-500
Ullin Ls. 150'-800'	Harrodsburg Ls.		0-800
	Ramp Creek Ls.		0-490
Fort Payne			0-610
Springville Sh.	State Pond 0-1.3		0-100

Fig. M-13—Columnar section of the Valmeyeran Series in southern Illinois.

formable with the underlying McCraney and the overlying Starrs Cave, but where the latter is absent it is overlain unconformably by the Burlington Limestone. It contains few macrofossils, but the abundant conodonts show a close correlation with the upper part of the Chouteau Limestone (Collinson, 1961, 1964).

### *Starrs Cave Limestone*

The Starrs Cave Limestone (Collinson, *in* Workman and Gillette, 1956, p. 31), the uppermost formation in the North Hill Group, is named for Starrs Cave on the Flint River near Burlington, Iowa, where the type section consists of 2.7-3.5 feet of oolitic, very light gray limestone containing many brachiopods and corals (NW NW 19, 70N-2W). Laudon (1931) referred to this unit as the *Schellwienella* Zone. In Illinois the Starrs Cave occurs only in western Hancock County (fig. M-9), where it is 2-12 feet thick but is not exposed. It is a buff to light brownish gray, coarsely oolitic, locally dolomitic limestone. It conformably overlies the Prospect Hill Siltstone and is unconformably overlain by the Burlington Limestone. It has an abundant macrofauna dominated by brachiopods and is correlated with the Chouteau Limestone (Collinson, 1961).

## VALMEYERAN SERIES

The Valmeyeran Series (Weller and Sutton, *in* Moore, 1933, p. 261-262) is named for Valmeyer, Monroe County, near which much of the series is exposed. It is the middle series of the Mississippian System and includes formations assigned to two series (Osagian and Meramecan) in other areas. The Valmeyeran Series underlies most of central and southern Illinois (fig. M-10) and includes strata from the top of the Chouteau Limestone upward to the base of the Shetlerville Member of the Renault Limestone (Swann, 1963) (figs. M-3, M-11, M-12, M-13). The series is thickest, over 1800 feet, in southeastern Illinois, and it thins to 600 feet or less before being truncated by erosion in northern Illinois (fig. M-10). It probably originally covered all of northern Illinois, as 200 feet of Valmeyeran strata are preserved in fault blocks in the Des Plaines Disturbance (Emrich and Bergstrom, 1962).

The Valmeyeran is characterized by lateral changes due to depositional pinchouts and lateral gradation. In the type area along the Mississippi River near St. Louis, the Valmeyeran is predominantly carbonate formations. In central Illinois the Burlington and Keokuk Limestones pinch out eastward and the lower part of the Valmeyeran consists of the thick Borden Siltstone (fig. M-14). Eastward, in southeastern Illinois, the Borden is replaced as the dominant unit by the very thick Ullin

Limestone and then by thick siliceous limestone of the Fort Payne Formation. The sediment of the Borden Siltstone was transported from the northeast by a major river and deposited in the inland sea as a delta that spread to and overlapped the Keokuk and Burlington carbonates. The deep-water, sediment-starved basin adjacent to the delta was later filled with Fort Payne and Ullin sediments (Swann et al., 1965; Lineback, 1966, 1968a, 1968b).

The overlying Salem and St. Louis Limestones are more persistent across the basin than the underlying units, but they, too, show facies that reflect water depth. Massive biocalcarenitic Salem grades laterally northward into fine-grained evaporite-bearing carbonates of the St. Louis (Lineback, 1972). Near the top of the Valmeyeran Series, the members of the Ste. Genevieve Limestone show rapid facies changes and the contact with the underlying St. Louis Limestone is stepped up and down in response to local lithologic changes.

Because of the complex facies variations in the Valmeyeran Series, knowledge of the relations between the many units has grown slowly, and the classification has been repeatedly changed (fig. M-15).

### *Borden Siltstone*

The Borden Siltstone (Cumings, 1922, p. 487) is named for Borden, Clark County, Indiana, where it is well exposed. It forms an elongate, tongue-shaped delta immediately east of the pinchout of the Burlington and Keokuk Limestones. It is continuous with the Borden Group of Indiana. The formation reaches more than 650 feet thick (fig. M-16), but it does not crop out in Illinois. The Borden in Illinois is dominantly gray to brownish gray, argillaceous, slightly calcareous, glauconitic, fine-grained siltstone, with lesser amounts of silty shale, some greenish gray coarse siltstone or fine sandstone, and light-colored, fossiliferous, cherty limestone. A persistent bed of coarse siltstone and fine sandstone is differentiated as the Bilyeu Member. Beds of fine sandstone and coarse siltstone near the base of the Borden are informally called the "Carper sand" (Moulton, 1926), and the name has been extended to similar beds in the Springville Shale (Lineback, 1968a). Some of the sandstones contain oil (Stevenson, 1964). The Borden Siltstone delta was deposited as a series of southward-developing imbricate topset, foreset, and bottomset beds (Swann et al., 1965; Lineback, 1966). Depositional dips of foreset bedding planes range from 25-120 feet per mile toward the delta margin. The delta was built into a deep-water basin. The "Carper sand" is now believed to have been deposited by multiple turbidity flows off the mouths of distributaries. At least six major turbidite systems as much as 300 feet thick have been recognized, some of which extend for many miles and lens out or grade into the Springville Shale. The Borden is laterally equivalent to the Warsaw Shale and is separated from it by a vertical cut-off at the

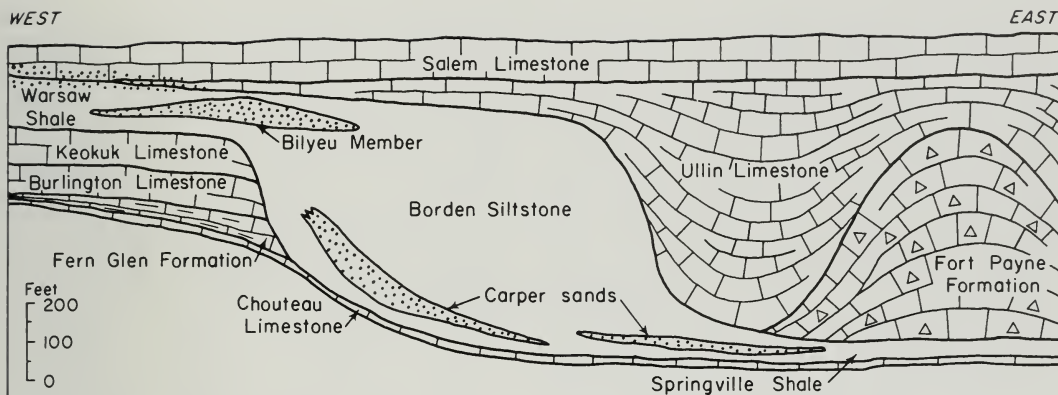


Fig. M-14—Diagrammatic east-west cross section across central Illinois showing the Borden Siltstone delta (after Lineback, 1968b).

position of the eastern pinchout of the Burlington and Keokuk Limestones (fig. M-14). In southern and southeastern Illinois, the Borden is separated from the equivalent Springville Shale by a vertical cut-off where the siltstone thins to less than 100 feet thick. The Borden overlies the Chouteau Limestone and is overlain by the Fort Payne Formation, or the Ullin, Salem, or St. Louis Limestones.

**Bilyeu Member**—The Bilyeu Member of the Borden Siltstone (Lineback, 1968a, p. 5) is named for Bilyeu Cemetery, Christian County, about 2 miles north of the type section, which is in the National Petroleum Company No. 1-A Bilyeu, Haldon et al., south well (NW NW SW 10, 13N-1E), where the member is 102 feet thick, extending from 1616 to 1718 feet deep. The Bilyeu consists of siltstone that is coarser than most of the Borden and also of fine sandstone. It is 0-150 feet thick and extends in the subsurface through Piatt, De Witt, Macon, Christian, Montgomery, Sangamon, and parts of adjacent counties in central Illinois. The Bilyeu Member extends westward beyond the eastern pinchout of the Burlington and Keokuk Limestones and, therefore, in that area is a member of the Warsaw Shale.

### Springville Shale

The Springville Shale (Savage, 1920, p. 169-178; Collinson and Scott, 1958a, p. 11), the basal formation of the Valmeyeran Series in southern Illinois, is named for the now abandoned village of Springville, Union County, which was located a short distance southeast of the type exposures in the bed and banks of a creek 4 miles southeast of Anna (SE 3, 13S-1W). Savage included in the Springville the thin Chouteau Limestone and the shale in the upper part of the New Albany Group, but these were removed by Collinson and Scott (1958a). The Springville Shale crops out discontinuously northward from the type exposures to Jonesboro, in a fault slice along the Shawneetown Fault in Saline County, and on the flanks of the Hicks Dome in Hardin County. The Springville is as much as 100 feet thick, but in most of southern Illinois it is less than 50, and in some places it is absent. The formation consists of greenish gray to dark brownish gray, clayey shale. A bed of soft glauconitic shale at the base is differentiated as the State Pond Member. In places, the Springville is mottled red and green and has been infor-

mally called the "calico shale." Lenses of the "Carper sand" are present in the areas of thicker shale. The shale is the deep-water equivalent of the Borden delta, and it is separated from the Borden Siltstone by vertical cut-off where the Borden thins to 100 feet (Lineback, 1966) (fig. M-14). The Springville overlies the Chouteau Limestone or, where the Chouteau is absent, the New Albany Group. It is overlain by the Fort Payne Formation or the Ullin Limestone.

**State Pond Member**—The State Pond Member of the Springville Shale (Collinson and Scott, 1958a, p. 5), at the base of the formation, is named for State Pond, an artificial lake a mile northwest of Jonesboro, Union County. The type section is in the south bank of the stream, below the spillway of the dam (NW SE 14, 12S-2W), where the member is 14-15 inches thick. It is a greenish gray, soft, glauconitic shale containing phosphate nodules. It has yielded conodonts and ostracodes typical of the Fern Glen, Burlington, and Keokuk Limestones and probably is a deep-water equivalent of all three formations.

### Meppen Limestone

The Meppen Limestone (Collinson, 1969, p. 12) is named for the village of Meppen, Calhoun County, and the type section is in a quarry 0.6 mile north of Meppen (SW NE 23, 12S-2W), where the formation is 7 feet thick, consists of buff, massive dolomite containing numerous small calcite geodes, and stands out as a distinct buff band in the quarry face. The formation occurs along the western edge of Illinois in an area extending from Calhoun County to Monroe County. It is well exposed in Calhoun and Jersey Counties and has a maximum thickness of 22 feet at Chautauqua, Jersey County (SE SE NE 13, 6N-12W). The Meppen is a tan or buff, very fine-grained, slightly crinoidal, dolomitic limestone or calcareous dolomite that commonly contains many calcite geodes 0.5-2 inches in diameter. The Meppen rests unconformably on the Chouteau Limestone, and at Chautauqua the relation is clearly angular. The Meppen is overlain conformably by the Fern Glen Formation, but north of the Lincoln Anticline the Fern Glen grades into the Burlington, and the Burlington overlaps the Meppen. The Meppen Limestone was called Sedalia in Illinois for many years (Rubey, 1952; Collinson et al., 1954) be-



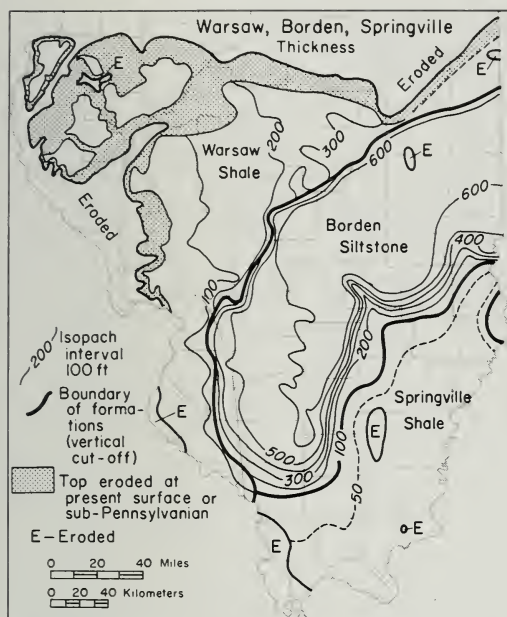


Fig. M-16—Thickness of the Warsaw Shale, Borden Siltstone, and Springville Shale.

cause of its lithologic similarity to the upper dolomitic portion of the Chouteau Limestone in Missouri, which had been named *Sedalia* by Moore (1928). However, the conodont faunas have shown that the Missouri *Sedalia* is Kinderhookian, whereas the Illinois "*Sedalia*" is Valmeyeran. The Meppen contains lower Valmeyeran conodonts, such as *Pseudopolygnathus multistriatus*, *Polygnathus communis carinus*, and *Bactrognathus hamatus*, but no diagnostic Kinderhookian species. The conodont *Gnathodus semiglaber*–*Pseudopolygnathus multistriatus* Zone occurs in the Meppen Formation (Collinson et al., 1962). Lithologically and faunally, the Meppen correlates better with the Pierson Limestone of central Missouri than with the *Sedalia*.

### Fern Glen Formation

The Fern Glen Formation (S. Weller, 1906b, p. 438) is named for Fern Glen Station on the Missouri Pacific Railroad, 20 miles west of St. Louis, where the type section, in the Missouri River bluffs, consists of 30–40 feet of red and green calcareous shale, shaly limestone, and a basal bed of massive, yellowish gray, magnesian limestone. The Fern Glen occurs in western Illinois from Randolph County north to Jersey County and in a belt extending northeast to southwestern Champaign County. It is typically exposed in the Chautauqua West Section, southern Jersey County (SW NE 13, 6N-12W), where it includes about 20 feet of calcareous shale, crinoidal limestone, and greenish gray chert (Collinson, 1969). It is also well exposed near Valmeyer, Monroe County (SE SE 3, 3S-11W). Throughout most of its extent, the Fern Glen is less than 50 feet thick, but in a few small areas in St. Clair, Sangamon, and Christian Counties, it approaches 100 feet. The formation consists of green and red calcareous shale and of gray, green, and red limestone and do-

lomite that is partly argillaceous. The lower part is generally shaly and noncherty, while the upper part is mainly limestone containing small nodules of greenish gray chert. The Fern Glen overlaps the underlying Meppen Limestone to rest on truncated older rocks, as old as the Maquoketa Shale Group. It grades vertically and laterally into the overlying Burlington Limestone, and the boundary is ordinarily drawn at the top of the youngest red or green bed. Fossils are abundant, notably brachiopods, corals, and crinoids. The more common fossils include the brachiopods *Spirifer vernonensis*, *S. rowleyi*, *Athyris lamellosa*, and *Leptaena rhomboidalis*, the bryozoan *Evactinopora sexradiata*, and the coral *Cyathaxonia arcuata*. The conodont *Bactrognathus*–*Polygnathus communis* Zone occurs in the Fern Glen Formation and the lower part of the Burlington Limestone.

### Burlington Limestone

The Burlington Limestone (Owen, 1852, p. 90–140; Hall, 1857, p. 190; Van Tuyl, 1925, p. 120) is named for the city of Burlington, Des Moines County, Iowa, where the formation is well exposed and about 70 feet thick. Owen used the term "Encrinital group of Burlington," Hall called it the Burlington Limestone, and Van Tuyl gave it its present definition by transferring the "beds of passage" (Montrose Chert Member) from the Burlington to the Keokuk. The Burlington extends from Henderson County in the northwest across a roughly triangular area southward to Jackson County and eastward to Iroquois County (fig. M-17). Good outcrops are found in the Mississippi River bluffs from Quincy, Adams County, to near Alton, Madison County (Collinson, 1964). In the vicinity of Quincy the lower 25 feet is relatively pure and is quarried as the "Quincy Lime." The

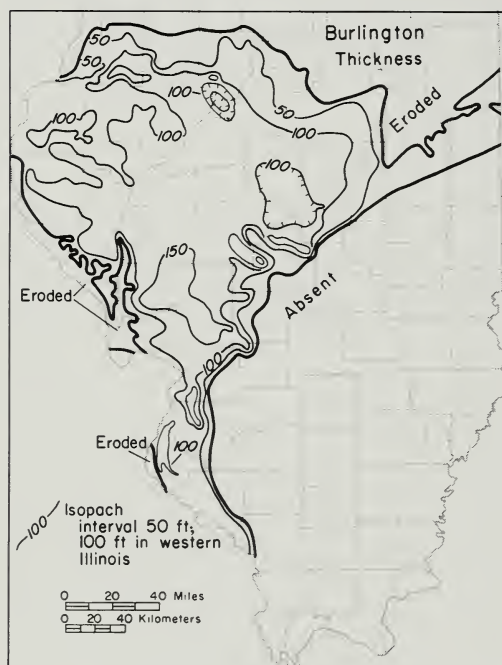


Fig. M-17—Thickness of the Burlington Limestone.

formation is commonly 100-150 feet thick, but it is as much as 200 feet thick in western Christian County. It terminates sharply to the east where overlapped by the Borden Siltstone (fig. M-14). In the northwestern part of its extent the Burlington consists largely of very pure, coarsely crystalline, light gray limestone in medium to thick beds. It contains a few beds of fine-grained, brownish gray, dolomitic limestone. Beds and nodular masses of light gray or white chert are common, especially in the middle and upper parts of the formation. Some beds are glauconitic. Large crinoid stems are abundant, and many beds are almost entirely crinoidal debris. The top of the Burlington is marked throughout a wide area by a bed 2-10 inches thick that contains many fish teeth and spines. Farther south the Burlington becomes more cherty, the crystalline limestone beds are few and fine-grained beds more common, and fossils are much less abundant. Chert in some places forms as much as 50 percent of the formation, but the chert is exceedingly lenticular and the amounts vary greatly (Rubey, 1952). In the southern area the Burlington and the overlying Keokuk can be distinguished only by their fossils and are generally referred to as the Burlington-Keokuk Limestone. The Burlington lies conformably on the Fern Glen and Meppen Formations, and unconformably on older beds where the Fern Glen and Meppen are absent. Among the common fossils restricted to the Burlington are *Cryptoblastus melo*, *Globoblastus norwoodi*, *Dictyoclostus burlingtonensis*, *Rhipidomella burlingtonensis*, *Stenocisma bisinuata*, *Spirifer grimesi*, *S. forbesi*, and *Spiriferella plena* (Weller and Sutton, 1940). Many crinoids have been described. The lower part of the Burlington Formation is in the conodont *Bactrognathus-Polygnathus communis* Zone, and the upper half is in the conodont *Bactrognathus-Taphrognathus* Zone (Collinson et al., 1971). The Burlington and the overlying Keokuk represent a shallow-water, largely clastic, carbonate sediment that was deposited on the western flank of the Illinois Basin while the Borden delta was expanding into the basin from the northeast.

## Keokuk Limestone

The Keokuk Limestone (Owen, 1852, p. 91, 92; Hall, 1857, p. 190; Van Tuyl, 1925, p. 142) is named for Keokuk, Lee County, Iowa. At the type locality about 70 feet of Keokuk Limestone overlying the Burlington Limestone is well exposed along Soap Creek and in the Mississippi River bluff near the mouth of the creek. The Keokuk occurs throughout much the same area as the underlying Burlington (fig. M-17), and it is well exposed along the Mississippi and Illinois Rivers in western Illinois. The Keokuk is 60-80 feet thick for much of its extent. Like the Burlington, the Keokuk is primarily a biocalcarenite. In the type region the lower 30 feet is very cherty and is differentiated as the Montrose Chert Member (Collinson, 1964). The part of the Keokuk above the Montrose is composed of beds of fossiliferous, crinoidal limestone interbedded with fine-grained limestone, argillaceous dolomite, and calcareous gray shale. The shale beds increase upward in number and thickness. The limestone is light gray, speckled with darker gray, brown, or black, and contains beds and nodules of chert. It is generally thinner bedded and darker than limestone of the Burlington, and the shale partings are more numerous. The

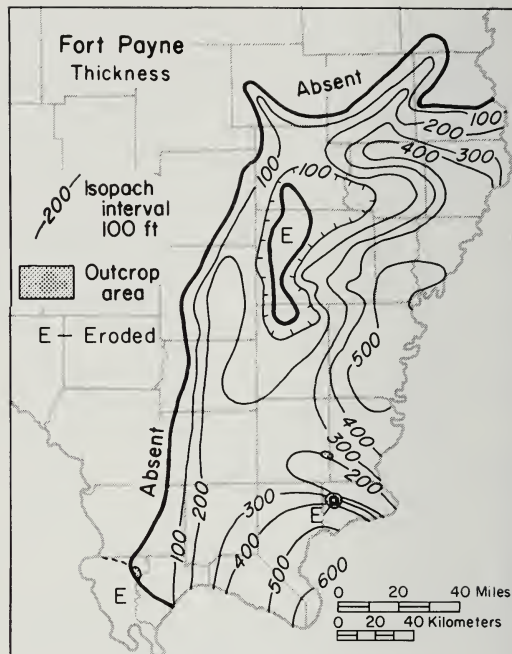


Fig. M-18—Thickness of the Fort Payne Formation.

contact with the overlying Warsaw Shale is gradational. In contrast to the crinoidal limestone of the Burlington, the Keokuk shows a great heterogeneity of skeletal remains, with abundant bryozoans, corals, and brachiopods. The Keokuk contains bryozoans in much greater abundance and diversity than does the Burlington, with *Archimedes* and *Worthenopora* especially common. Distinctive brachiopods include *Spirifer logani*, *Dictyoclostus crawfordsvillensis*, *Orthotetes keokuk*, and *Rotaia subtrigonia* (Weller and Sutton, 1940). The conodont *Gnathodus texanus-Taphrognathus* Zone essentially coincides with the Keokuk Formation (Collinson et al., 1971).

**Montrose Chert Member**—The Montrose Chert Member of the Keokuk Formation (Keyes, 1895, p. 320) is named for Montrose, Lee County, Iowa, and the type section consists of 30 feet of very cherty limestone at the base of the Keokuk Limestone where it is exposed along the Mississippi River between Montrose and Keokuk. Earlier, these beds had been termed the "Keokuk cherty limestones" (Owen, 1852) or the "cherty beds of passage" separating the Keokuk and Burlington (Hall, 1857). The Montrose Chert Member is generally about 30 feet thick and consists of gray, medium- to coarse-grained, fossiliferous limestone and light gray dolomite in beds 2-10 inches thick. It contains nodules and beds of blue-gray chert. The chert is dominant in many places and commonly is strongly brecciated (Collinson, 1964).

## Warsaw Shale

The Warsaw Shale (Hall, 1857, p. 54-56) is named for Warsaw, Hancock County, and the exposure in Geode Glen at Warsaw has become the type section (NW NW 10, 4N-9W) (Collinson, 1964). The Warsaw is widely

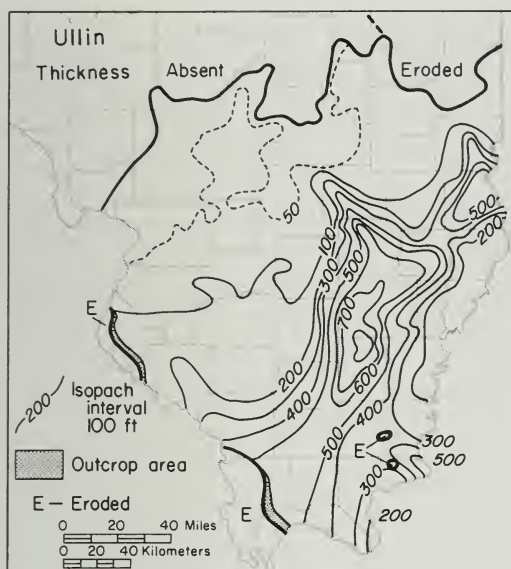


Fig. M-19—Thickness of the Ullin Limestone.

present in the bluffs of the Mississippi and Illinois Valleys in western and southwestern Illinois. It consists of as much as 300 feet of siltstone in west-central Illinois (fig. M-16), but it thins to less than 100 feet in the outcrop area, where it consists of gray shale containing beds of argillaceous limestone. Quartz geodes are common and locally abundant; some are replacements of fossils. Some contain petroleum. The Warsaw is fossiliferous, with brachiopods, bryozoans, and crinoids especially common. The corkscrew bryozoan, *Archimedes* (fig. M-4), is so abundant that the formation was called the *Archimedes* limestone in early reports. Coarse silt and fine sandstone differentiated as the Bilyeu Member of the Borden Siltstone in central Illinois continues westward into the Warsaw Shale, where it becomes a member of the Warsaw. The Warsaw is overlain by the Sonora Formation or by the Ullin, Salem, or St. Louis Limestones. The Warsaw Shale overlies the Keokuk Limestone, and where the Keokuk and Burlington Limestones pinch out eastward the Warsaw is separated from the Borden Siltstone by a vertical cut-off (Lineback, 1966) (fig. M-14).

### Sonora Formation

The Sonora Formation (Keyes, 1895, p. 320) is named for the now extinct village of Sonora, Hancock County, about a mile north of the type section of the formation in the Sonora quarries (SE NW 31, 6N-8W), where about 20 feet of sandy, cross-bedded dolomite grades to porous, dolomitic sandstone. The Sonora crops out most widely in the Mississippi River bluffs and along tributary valleys in Adams and Hancock Counties. It is typically exposed at Jackson Cemetery, Hancock County (SE NW 14, 7N-8W), where it is more than 20 feet thick and consists of beds of argillaceous and dolomitic, cross-bedded sandstone alternating with sandy shale. The Sonora is generally about 20 feet thick between Niota and Hamilton, but

elsewhere it is thinner, becoming only 2-3 feet thick in the Warsaw area (Collinson, 1964). Although characteristically a sandy formation, the lithology varies laterally and vertically. The dolomite is arenaceous to argillaceous and sparsely fossiliferous, but fragments of fenestellid bryozoans occur throughout. The sandstone is generally light buff, dolomitic, argillaceous, and fine grained. The shale is generally greenish gray and sandy. Both Salem and St. Louis overlie the Sonora in places. The contact with the overlying St. Louis varies from conformable to erosional. In most localities where the contact is exposed, the lower part of the St. Louis is brecciated, possibly by the solution of a layer of gypsum or anhydrite. The Sonora grades laterally into the Salem Limestone and the upper part of the Warsaw Shale (Collinson, 1964). The Sonora lies within the conodont *Taphrognathus varians*–*Apatognathus* Zone (Collinson et al., 1971).

### Fort Payne Formation

The Fort Payne Formation (Smith, 1890, p. 155-156) is named for Fort Payne, De Kalb County, Alabama. It consists of dark, very fine-grained, siliceous, cherty limestone. The Fort Payne is confined to southern Illinois. It is over 610 feet thick in Pope County, and thins northward and westward (fig. M-18). The best exposure of the Fort Payne in Illinois is in a fault slice along the Shawneetown Fault near the former community of Horseshoe, Saline County, where at least 150 feet of steeply dipping beds are exposed. The Fort Payne is also exposed on the flanks of Hicks Dome in Hardin County, where it is largely weathered to chert. Eleven feet of chert exposed in the bluff in Alexander County west of Ullin, Pulaski County, is also assigned to the Fort Payne. In the subsurface the Fort Payne consists of quartz and carbonates in silt- and clay-sized particles. In the lower part it contains nodular chert and fossils, especially crinoids, and some clay minerals. The dark color is caused by pyrite and organic matter. The Fort Payne overlies the Springville Shale, the Chouteau Limestone, or the lower portion of the foreset slope of the Borden Siltstone delta in southern Illinois. It is overlain by the Ullin Limestone. The Fort Payne occurs as an irregular tongue-shaped body that partially filled a deep-water basin bordered by the foreset slopes of the Borden delta in southern Illinois and southeastern Indiana (Lineback, 1966). It is the northernmost extension of a large body of siliceous and cherty rocks that extends through western Kentucky to Mississippi and Alabama and eastward to the Appalachian Mountains.

### Ullin Limestone

The Ullin Limestone (Lineback, 1966, p. 29-34) is named for Ullin, Pulaski County, near which the type section was compiled from three exposures (secs. 14, 21, and 22, 14S-1W), which have a total thickness of about 630 feet. Its maximum thickness is more than 800 feet in Hamilton County and it thins generally northward (fig. M-19). It is exposed in the Mississippi River bluffs in Monroe, St. Clair, and Madison Counties and in southern Illinois in Union, Pulaski, and Hardin Counties. The Ullin Limestone is largely light-colored, fine- to coarse-grained limestone (fig. M-1F) that is rich in bryozoans and crinoids. It overlies the Fort Payne Formation, or the Borden, Springville, Warsaw, or Chouteau Formations

where the Fort Payne is absent. It underlies the Salem Limestone and pinches out beneath it in western Illinois. The Ullin can generally be subdivided into two members, the Harrodsburg Limestone Member, above, and the Ramp Creek Limestone Member, below. The Harrodsburg is generally lighter colored, coarser grained, less cherty and less argillaceous than the Ramp Creek, whereas the Ramp Creek contains more crinoidal debris and is glauconitic in places. However, the Harrodsburg and Ramp Creek Members are similar in many places, and in about one-third of the area of the Ullin they cannot be differentiated. Where the Ullin is thickest, in Hamilton County, both members are light-colored calcarenite rich in bryozoans. Where the Ullin is thin, as it is on the crest of the Borden delta and on the highest parts of the Fort Payne tongue, both members become more crinoidal and are indistinguishable. The Ullin Limestone filled deep-water trenches bordered by depositional slopes of the Borden delta and the Fort Payne Formation.

**Ramp Creek Limestone Member**—The Ramp Creek Limestone Member of the Ullin Limestone (Stockdale, 1929, p. 233-242) is named for the village of Ramp Creek, Monroe County, Indiana, and the type section is a near-by exposure of 21 feet of siliceous and argillaceous limestone (NW NW 35, 8N-1W). The name "Ramp Creek" was originally applied to the lower part of the Harrodsburg Limestone, but Harrodsburg was later restricted to the upper, purer limestone (Smith, 1965). The Ramp Creek in Illinois is the lower, cherty, argillaceous limestone of the Ullin (Lineback, 1966). The Ramp Creek is 0-490 feet thick. It includes the brachiopod *Marginirugus magnus* Zone.

**Harrodsburg Limestone Member**—The Harrodsburg Limestone Member of the Ullin Limestone (Hopkins and Siebenthal, 1897, p. 296-297; Stockdale, 1939, p. 72-73; Smith, 1965, p. 11; Lineback, 1966, p. 33) is named for Harrodsburg, Monroe County, Indiana. The original type section was destroyed by highway construction, but an exposure 1 mile north of Harrodsburg is used as a standard reference section (Shaver et al., 1970). The Harrodsburg Member is exposed along the Mississippi Valley in western and southwestern Illinois and in Hardin County in southeastern Illinois. It is over 800 feet thick in Hamilton County, but it thins northward and pinches out at the margin of the formation. It consists of light-colored bryozoan and crinoid debris. In Monroe County the Harrodsburg strata were included in the Kidd Member of the Salem by Baxter (1960a), but they were excluded from the Kidd by Lineback (1972).

## Salem Limestone

The Salem Limestone (Cumings, 1901, p. 233) is named for Salem, Washington County, Indiana, where it is extensively quarried for Indiana building stone. It was called "Spergen Hill" or "Spergen" limestone in early reports. No type section was designated, but a quarry 0.8 mile east of Salem is considered the principal reference section (Shaver et al., 1970). The Salem Limestone forms prominent outcrops in Illinois in parts of Hardin County, along the Mississippi River in Randolph (fig. M-1D), Monroe, and Madison Counties, and in places in western Illinois. It is over 500 feet thick in southeastern Illinois and thins northward (fig. M-20). Small patches occur northwest of the area mapped. The Salem generally overlies the Ullin, but where the Ullin pinches out northward the Salem rests on the Warsaw Shale or the Sonora Formation. The Salem is overlain by the St. Louis Limestone. The Salem is a biocalcarene consisting of

rounded, broken, fossil fragments and whole small fossils, commonly with banded, oolitic-like overgrowths, that are imbedded in a matrix that ranges from micrite to sparite. Endothyrid foraminifers are commonly abundant (fig. M-4). Minor lithologies in the Salem include biocalcitulite, biocalcirudite, sucrosic dolomite, dolomitic limestone, fine-grained limestone, fossiliferous crystalline limestone, sandstone, chert, and the evaporites anhydrite and gypsum. Some fine-grained, silty, dolomitic beds weather yellow and form reentrants on the weathered faces. The Salem differs from the underlying Ullin by having a greater variety of fossils and fossils with banded overgrowths. In the outcrop area in Monroe County and extending from Prairie du Rocher, Randolph County, to Dupu, St. Clair County, the Salem is divided into the Kidd (at the base), Fults, Chalfin, and Rocher Members, largely on the basis of differences in textures (Baxter, 1960a). The Kidd and Fults Members are lithologically and faunally similar to the type Salem in Indiana. The upper part of the Salem grades laterally into the St. Louis Limestone in Madison County and northward (Lineback, 1972). The lower part can be identified into Christian County and northward, but the biocalcarene grades laterally into dolomitic limestone and fossiliferous limestone that contain evaporites and sandstone in places. The lateral gradation is the result of the southward deepening of the water from shallow water near the shore in north-central Illinois to deeper water near the center of the Illinois Basin.

**Kidd Member**—The Kidd Member of the Salem Limestone (Baxter, 1960a, p. 19-22; Lineback, 1972, p. 5), the basal member, is named for Kidd, Monroe County, and the type section is in the Mississippi River bluffs east of the village (NE NE 1, 5S-10W). As originally defined, it included the Harrodsburg Member of the Ullin Limestone, but it was

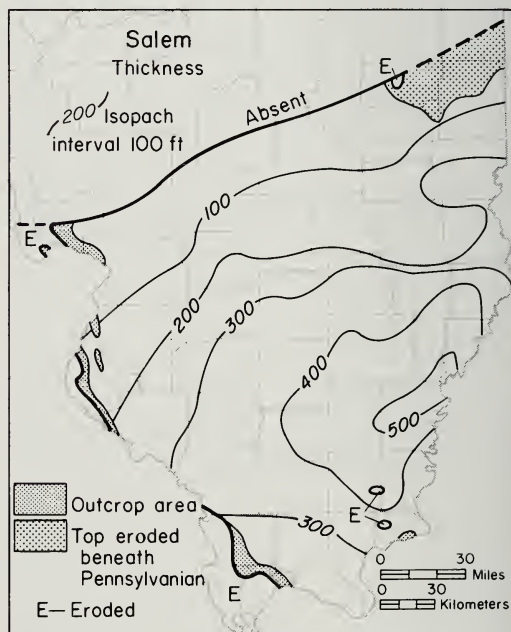


Fig. M-20—Thickness of the Salem Limestone.

restricted by Lineback to the biocalcarenite below the Fults Member and above the Ullin. In the type section the Kidd consists of about 22 feet of chert-free, high-calcium biocalcarenite, largely made up of medium and coarse grains of fragmented fossils, mostly crinoid columnals and bryozoan detritus, in beds 2-3 feet thick. The foraminifers *Endothyra* sp., *Tournayella* sp., and *Globoendothyra* sp. are present. *Globoendothyra baileyi* is common and becomes more common in the upper half of the member.

**Fults Member**—The Fults Member of the Salem Limestone (Baxter, 1960a, p. 22-24) is named for Fults, Monroe County, and the type section is in the bluffs three-fourths of a mile northwest of the town (SE NE 20, 4S-10W), where the member is 29.4 feet thick. It is 25-34 feet thick in the outcrop area in Monroe and St. Clair Counties. The Fults Member consists largely of thin- to medium-bedded, fine-grained, silty, cherty, more or less dolomitic limestone, but it contains beds of medium-grained limestone composed of fragmented fossils. *Globoendothyra baileyi* and *Eoendothyranopsis spiroides* are common.

**Chalfin Member**—The Chalfin Member of the Salem Limestone (Baxter, 1960a, p. 24-27) is named for the village of Chalfin Bridge, Monroe County, and the type section is in the Mississippi River bluffs 1 mile southwest of the village (NE SW 7, 4S-10W), where the member is 39.5 feet thick. It is 26-57 feet thick in the outcrop area. The Chalfin consists of varying thicknesses of fine-grained limestone; fine- to medium-grained, fossiliferous, locally oolitic limestone; and semilithographic limestone, some of it brecciated. The lower 10 feet is predominantly a calcarenite composed of bryozoan detritus, crinoid columnals, microcrystalline pellets, and a few oolites. *Eoendothyranopsis* group *pressus-rarus*, *Koninckopora sahariensis*, *K. inflata*, *Septabrunsiina*, and profuse *Calcisphaera* characterize the Chalfin.

**Rocher Member**—The Rocher Member of the Salem Limestone (Baxter, 1960a, p. 27-29), the uppermost member, is named for Prairie du Rocher, Randolph County, and the type section is in the Mississippi River bluffs above a large spring 1 mile northwest of the town, where the member is 69.3 feet thick. It thins northward to 10-15 feet at Valmeyer,

Monroe County. The Rocher is mined for high-calcium limestone just north of the type section. It is composed largely of marine fossils, predominantly Foraminifera, but it also includes crinoid and bryozoan fragments, brachiopods, corals, and echinoids. Endothyrids and calcareous spheres with calcite centers, questionable fossils classified as *Calcisphaera*, are abundant (Baxter, 1960b). The microfauna is similar to that of the Chalfin and the lower part of the St. Louis. The limestone varies from slightly oolitic to oolite. It occurs in thick, cliff-forming beds, broken by an occasional thin bed.

## St. Louis Limestone

The St. Louis Limestone (Engelmann, 1847, p. 119-120; Ulrich, 1904, p. 103) is named for St. Louis, Missouri, where it is extensively exposed. No type section was designated. The St. Louis is typically exposed in Illinois in the Mississippi River bluffs at Alton, Madison County (Collinson et al., 1954) (fig. M-1B). It is also well exposed in the Mississippi and Illinois Valleys in western and southern Illinois (fig. M-1D) and along the Ohio River in Hardin County (fig. M-21). The St. Louis is 500 feet thick in southeastern Illinois and thins northward to less than 200 feet before being truncated by pre-Pennsylvanian erosion. The St. Louis Limestone in Illinois is characterized by fine-grained, micritic to lithographic, cherty limestone, but it contains beds of dolomite, crystalline limestone, fossiliferous limestone, and evaporites. The evaporites are represented in the outcrop areas by limestone breccias. The outcrop areas of the St. Louis are characterized by abundant sink holes. The St. Louis overlies the Salem Limestone except in the parts of western Illinois where it lies on the Warsaw Shale or the Sonora Formation. It is overlain by the Ste. Genevieve Limestone. The lower part of that formation grades laterally into the St. Louis Limestone, and in those places the formations are separated by a vertical cut-off. The rugose coral *Lithostrotionella* is common and characteristic (fig. M-4). In the St. Louis-Alton area the lower part of the St. Louis is included in the conodont *Taphrog-nathus varians*—*Apatognathus* Zone and the upper part in the *A. scalenus*—*Cavusgnathus* Zone. The upper St. Louis has common *Eoendothyranopsis*, *Koninckopora pruvosti*, and large archaeodiscids.

## Genevieve Stage

The Genevieve Stage (Swann, 1963, p. 20-21) is named for the Ste. Genevieve Limestone, the type section for which is at Ste. Genevieve, Missouri. It is the only stage at present differentiated in the Valmeyeran Series and covers only the latest part of Valmeyeran time (fig. M-3). It consists of all the strata contemporaneous with the Ste. Genevieve Limestone where its top corresponds with the last occurrence of *Platycrinites penicillus*. The *Platycrinites*—*Talarocrinus* boundary is the basis for the time plane separating the Valmeyeran and Chesterian Series. It falls within the Renault Limestone at the top of the Levias Member. The base of the Genevieve Stage is less well defined, but in the Illinois Basin it is placed at the top of the St. Louis

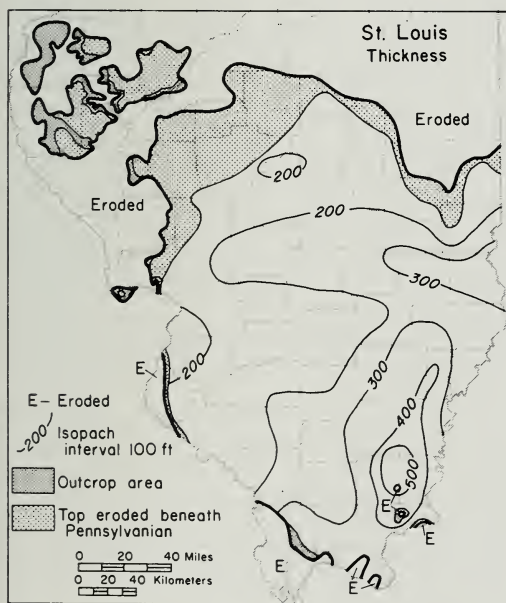


Fig. M-21—Thickness of the St. Louis Limestone.

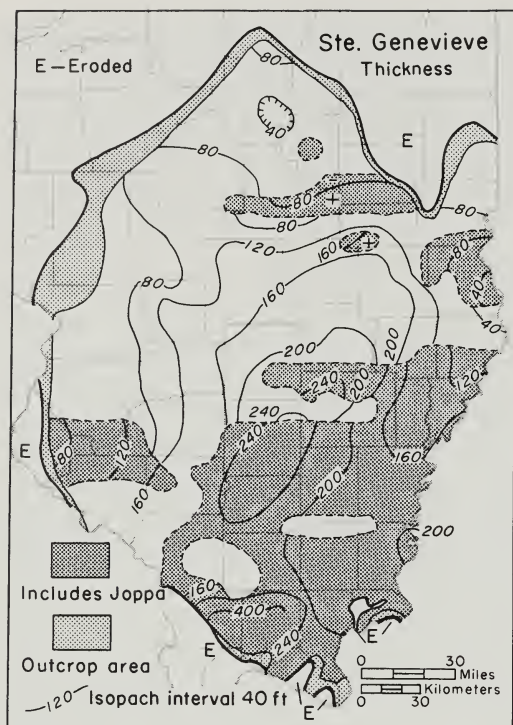


Fig. M-22—Thickness of the Ste. Genevieve Limestone.

Limestone, which is the base of the *Gnathodus bilineatus*–*Cavusgnathus charactus* Zone, somewhat higher than the disappearance of *Lithostrotion* and *Lithostrotionella* with large corallites, where it was originally placed.

### Ste. Genevieve Limestone

The Ste. Genevieve Limestone (Shumard, 1860, p. 406) is named for Ste. Genevieve, Missouri, where it is about 100 feet thick, and the type section consists of outcrops in the bluffs along the Mississippi River 1-4 miles southeast of Ste. Genevieve. The Ste. Genevieve overlies the St. Louis Limestone and underlies the Aux Vases Sandstone throughout much of the southern half of the Illinois Basin. It crops out from the vicinity of Alton, Madison County (fig. M-1B), south along the Mississippi Valley to Randolph County and from Union County, where it is about 300 feet thick, eastward across southern Illinois to Hardin County, where it averages about 250 feet thick (fig. M-22). The Ste. Genevieve is generally light gray, but some beds of oolite (fig. M-1E) are nearly white. Chert is common and is generally gray, but in some places it is black. Thin beds of sandstone and sandy limestone, some traceable for many miles, occur mainly in the upper half of the formation. The sandstone is generally calcareous, light greenish gray, and very fine grained. A little shale, mainly dark greenish gray but locally red, purple, or green, occurs in the upper part of the formation. The Ste. Genevieve is subdivided into four

members: the Fredonia Limestone Member at the base, the Spar Mountain Sandstone Member, the Karnak Limestone Member, and the Joppa Member (sandstone, limestone, dolomite, and shale). Near its western border the Ste. Genevieve has a conglomeratic bed at its base and rests unconformably on the eroded top of the St. Louis Limestone. Elsewhere the two formations appear to be conformable and, in the transition zone, beds with Ste. Genevieve lithology intertongue with beds with St. Louis lithology. The contact is placed below the lowest prominent oolitic bed. The contact between the Ste. Genevieve and the overlying Aux Vases Sandstone is conformable, but it is marked by a series of downward steps to the west as the upper limestone beds grade westward into sandstone. Weathered surfaces of the Ste. Genevieve generally show abundant fossils, mainly crinoid fragments. *Platycrinites* (“*Platycrinus*”) *penicillus* and *Pugnoides ottumwa* are characteristic, although they occur rarely in older or younger strata. The Ste. Genevieve is in the lower part of the *Gnathodus bilineatus*–*Cavusgnathus charactus* Zone (Collinson et al., 1971). The Ste. Genevieve Formation extends into eastern Missouri, southwestern Indiana, and western Kentucky. The Pella beds of Iowa are correlated with the Ste. Genevieve.

**Fredonia Limestone Member**—The Fredonia Limestone Member of the Ste. Genevieve Limestone (Ulrich and Smith, 1905, p. 24, 40; Swann, 1963, p. 27, 66), the lowest and thickest member, is named for Fredonia, Caldwell County, Kentucky (14-I-18). The Fredonia originally included the dominantly limestone section from the base of the Rosiclare Sandstone to the top of the underlying St. Louis Limestone, but it was restricted by Swann (1963) to the limestone between the base of the Spar Mountain Member and the St. Louis Limestone. The Fredonia is generally 80-100 feet thick, but from Effingham County north to Coles County it thins rapidly to 20 feet or less. The limestone is light gray, mainly oolitic, cross-bedded, and crinoidal, but it includes some darker lithographic limestone beds like those in the St. Louis below.

**Spar Mountain Sandstone Member**—The Spar Mountain Sandstone Member of the Ste. Genevieve Limestone (Tippie, 1945, p. 1657), which overlies the Fredonia Limestone Member, is named for Spar Mountain, Hardin County, where the type section, on the south-facing slope (NE 4, 12S-9E), consists of 8-15 feet of light gray to greenish gray, calcareous, glauconitic sandstone or siltstone grading to very sandy limestone. The Spar Mountain extends throughout most of the area of the Ste. Genevieve (fig. M-22). Lenses of similar sandstone and sandy calcarenite occur sporadically at other levels in the Ste. Genevieve, and the Spar Mountain is difficult to differentiate from them in some areas. It is erratic in thickness and has a varied lithology, including beds of dolomite, limestone, sandy limestone, sandstone, and thin shale. In the northern part of its extent, it is as much as 40 feet thick. In the western part of the basin—for example, in western Washington County—the Spar Mountain grades laterally into the Aux Vases Sandstone and is separated from it by vertical cut-off.

**Karnak Limestone Member**—The Karnak Limestone Member of the Ste. Genevieve Limestone (Swann, 1963, p. 28-29, 71) is named for Karnak, Pulaski County, about 4 miles southeast of the type section in Johnson County (SW 32, 13S-2E, and NW 32, 14S-2E), where the top 16 feet of an estimated 20-25 feet of limestone is exposed in cuts on Illinois Highway 37. The Karnak is a persistent unit and is generally traceable throughout the area of the Ste. Genevieve (fig. M-22), but in western Washington County it thins and grades laterally into the Aux Vases Sandstone. The Karnak is generally 10-35 feet thick. The limestone is relatively pure, oolitic, crinoidal, mostly light gray, and cross-bedded.

**Joppa Member**—The Joppa Member of the Ste. Genevieve Limestone (Swann, 1963, p. 29, 71), the uppermost member, is named for Joppa Junction, Johnson County, about half a mile west of the type section (SW SW 32, 13S-2E), where the member comprises 32 feet of shale and limestone overlying the Karnak Limestone Member. In southeastern Illinois the Joppa generally includes prominent limestones that allow it to be readily separated from the Aux Vases Sandstone. However, in most of the western and northern parts of the basin it is impractical to separate the Joppa from the Aux Vases, and there the Joppa is terminated by a vertical cut-off. The Joppa is 20-50 feet thick. Most of the limestone is sandy and oolitic, and part of it is red and hematitic. The sandstone is generally very fine grained and calcareous, resembling that of the Aux Vases. The shale is largely dark greenish gray, but red and green shales are common.

## POPE MEGAGROUP

The Pope Megagroup (Swann and Willman, 1961, p. 481-482), named for Pope County in southern Illinois, comprises sandstone-shale units alternating with limestone-shale units of late Valmeyeran and Chesterian age that overlie the Mammoth Cave Limestone Megagroup and underlie the Pennsylvanian System and younger rocks (fig. 14). The lateral extent of the Pope Megagroup in Illinois is the same as that of the base of the Ste. Genevieve Limestone to the north (fig. M-22) and that of the Aux Vases Sandstone to the south (fig. M-23). The outcrop area runs along and near the Mississippi and Ohio Rivers from Alton, Madison County, south to Grand Tower, Jackson County, and then eastward through Hardin County. The Pope thickens from its truncated edge on the north to about 1300 feet near its southern border, only slightly thicker than the Chesterian Series (fig. M-26). The Pope Megagroup is roughly equivalent to the Chesterian Series, but it includes the Spar Mountain Member of the Ste. Genevieve (Valmeyeran) to the north and the Aux Vases (Valmeyeran) in most of its extent. Near its southeastern border the base of the Pope is locally a little higher than that of the Chesterian. The Pope is generally conformable on the Mammoth Cave Megagroup, except for minor erosional channels at the base of the Aux Vases Sandstone. It is separated from the overlying Pennsylvanian System by a major unconformity that has a relief of as much as 450 feet.

## Aux Vases Sandstone

The Aux Vases Sandstone (Keyes, 1892, p. 295) is named for the Aux Vases River in Ste. Genevieve County, Missouri, and the type section consists of outcrops in the Mississippi River bluffs at the mouth of the Aux Vases River (N $\frac{1}{2}$  NW $\frac{1}{4}$  13, 37N-9E). The Aux Vases consists of sandstone, siltstone, and minor amounts of shale and, locally, dolomite and limestone. It occurs in much

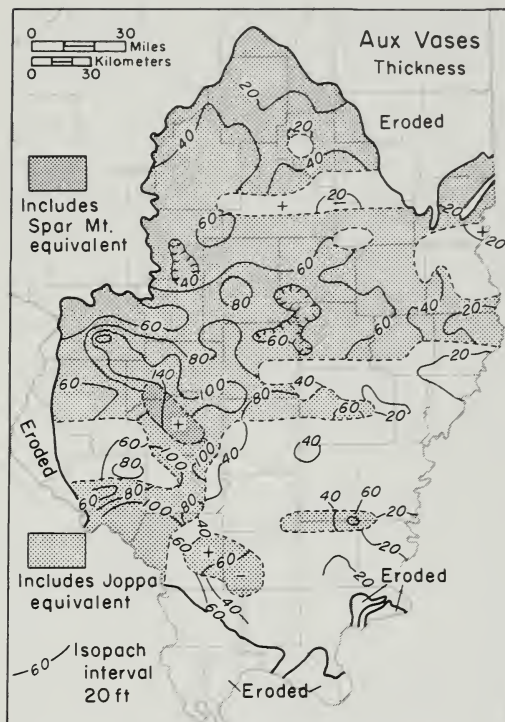


Fig. M-23—Thickness of the Aux Vases Sandstone.

of the area of the Chesterian Series (fig. M-23). It crops out along the Mississippi River Valley in St. Clair, Monroe, and Randolph Counties, being particularly well exposed in the bluffs 2-3 miles southeast of Prairie du Rocher, Randolph County. In southern Illinois it crops out principally in Union, Johnson, and Hardin Counties. The thickness map of the Aux Vases (fig. M-23) shows discontinuities because in some areas the base is dropped to include the equivalents of the underlying Joppa Member of the Ste. Genevieve Limestone where the Joppa grades to sandstone and shale. In a much smaller area, the base is dropped to include equivalents of the Spar Mountain Sandstone Member where the Karnak Member lenses out or grades to sandstone (Swann and Atherton, 1948; Swann, 1963). In the area where the Joppa Member is present, all of the Aux Vases is assigned to the Rosiclare Sandstone Member. In southeastern Illinois the Aux Vases is commonly 20-40 feet thick, but north and west of there, where it includes Joppa equivalents, it is 60-80 feet thick. It thickens to the west and reaches a maximum of 130-160 feet in the small area where it includes Joppa and Spar Mountain equivalents. The sandstone is light gray to greenish gray, locally pink or red, hematitic, calcareous, very fine to fine grained. In many places it grades to coarse siltstone. Lenses of brown dolomite occur in the lower part. The shale in the Aux Vases is dark gray and sandy, and the siltstone is green or gray. Where it includes Joppa equivalents, the Aux Vases commonly contains beds or lenses of gray, yellow, brown, pink, or red oolitic limestone.

**Rosiclare Sandstone Member**—The Rosiclare Sandstone Member of the Aux Vases Sandstone (Ulrich and Smith,

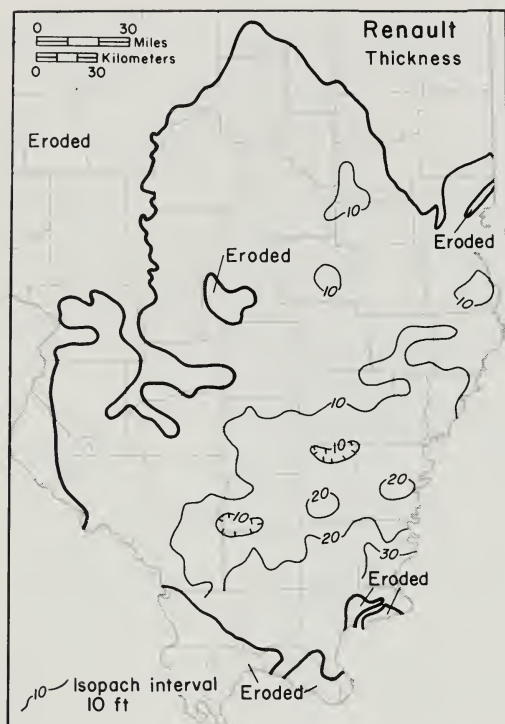


Fig. M-24—Thickness of the Renault Limestone.

1905, p. 24, 40; Swann, 1963, p. 80) is named for Rosiclare, Hardin County; its type section is in the Ohio River bluffs just below the town (NW SE and SW SE 5, 13S-8E). As originally defined, the Rosiclare Sandstone was a member of the Ste. Genevieve Limestone, and the name was widely misapplied to the sandstone now called the Spar Mountain Sandstone Member of the Ste. Genevieve. However, the type Rosiclare was found to be equivalent to the Aux Vases Sandstone (Swann and Atherton, 1948; Swann, 1963). The Rosiclare Sandstone has long been correctly correlated throughout the eastern part of the Illinois Basin, where it is an important oil producer. Consequently, the name "Rosiclare" is retained for a member of the Aux Vases. The Rosiclare is the main body of the Aux Vases in the area where it overlies the Joppa Member of the Ste. Genevieve and, therefore, does not include lateral equivalents of the Ste. Genevieve Limestone. It is commonly 20-40 feet thick.

### Cedar Bluff Limestone Group

The Cedar Bluff Limestone Group (Swann, 1963, p. 63) is named for the quarry of the Cedar Bluff Limestone Company, formerly the Ohara quarry, southeast of Princeton, Caldwell County, Kentucky (S<sup>1</sup>/<sub>2</sub> 21-H-20). It consists of the Downeys Bluff, Yankeetown, and Renault Formations in areas where these formations are dominantly limestone (fig. M-25). It occurs in southeastern Illinois and is exposed in Hardin County. It was originally called the Ohara Limestone, but the name Ohara is widely used for the Karnak Member of the Ste. Genevieve in the subsurface. The Valmeyeran-Chesterian contact falls within

the Cedar Bluff Group at the top of the Levias Limestone Member of the Renault Formation.

### Renault Limestone

The Renault Limestone (S. Weller, 1913, p. 120, 122; Swann, 1963, p. 79), the lower part of which is Valmeyeran in age and the upper part Chesterian, is named for Renault Township, Monroe County, and the type section consists of exposures in the valley of Horse Creek. A typical exposure 4 miles northeast of the village of Renault on the south side of Dry Fork (SE SW 23, 4S-9W) is accepted as the type section (Swann, 1963). The interbedded sandstone and shale unit overlying the limestone portion in the type area was originally regarded as the upper part of the Renault but now is assigned to the Yankeetown. The Renault is a widespread, relatively thin formation, averaging only about 8 feet thick (fig. M-24), but it ordinarily stands out as a high-resistive unit on electric logs. The Renault thickens to more than 40 feet in part of Johnson County. It consists of a lower relatively pure limestone, the Levias Member (Valmeyeran), and an upper sandy limestone, the Shetlerville Limestone Member (Chesterian), which in turn includes a persistent sandstone bed (Popcorn Sandstone Bed) at its base. In some earlier reports the Levias Member was miscorrelated with strata below the Aux Vases Sandstone and it was therefore classified as a member of the Ste. Genevieve Formation.

**Lvias Limestone Member**—The Levias Limestone Member of the Renault Formation (Sutton and J. M. Weller, 1932, p. 430, 439) is named for Levias, Crittenden County, Kentucky, and the type locality is just east of the town (10-J-16). It was originally the uppermost member of the Ste. Genevieve Limestone and was introduced as a replacement of the earlier name "Lower Ohara," but it was assigned to the Renault Limestone when it was found to overlie the Aux Vases Sandstone. The Levias is well developed in and near Hardin County, but north and west of there it is not easily distinguished and it is recognized only sporadically north of Lawrence County and west of Franklin County. In Hardin County the Levias commonly is 10-25 feet thick, but it has a maximum thickness of 35 feet. The limestone is relatively pure, cross-bedded, medium- to coarse-grained, white oolite containing some pink and light green ooliths. It contains some fine-grained limestone, and a few feet at the base is sandy. The Levias Limestone contains *Platycrinites penicillus* and is the top of the Valmeyeran Series.

**Shetlerville Limestone Member**—The Shetlerville Limestone Member of the Renault Formation (S. Weller, in S. Weller et al., 1920, p. 123; Swann, 1963, p. 82) is named for Shetlerville, Hardin County. Weller designated it a formation, citing exposures of about 30 feet of limestone just east of Shetlerville as the type section. Swann (1963) put the upper shaly part in the Yankeetown, restricted the Shetlerville to 15 feet of limestone exposed in a quarry one-fourth of a mile south of Shetlerville (SE NE SW 35, 12S-7E), and classified it as a member of the Renault. Most of the limestone is dark greenish or brownish gray, sandy, and oolitic. The basal portion grades to sandstone and is named the Popcorn Sandstone Bed. Some beds are light colored and resemble the underlying Levias Member. The basal contact is sharp and may be unconformable. The Shetlerville contains the crinoid *Talarocrinus* (fig. M-4) and is the basal part of the Chesterian Series.

**Popcorn Sandstone Bed**—The Popcorn Sandstone Bed in the base of the Shetlerville Member of the Renault Limestone (Swann, 1963, p. 32) is named for Popcorn Spring, 700 feet

north of Popcorn Church in Lawrence County, Indiana (SE SE SW 5, 6N-2W), where it forms the base of the Paoli Formation. It is a bed of sandstone, shale, or impure limestone a few inches or a few feet thick. It occurs in Hardin County, but it is not widely recognized in Illinois.

## CHESTERIAN SERIES

The Chesterian Series (Worthen, 1860, p. 312-313; Swann, 1963, p. 20), the uppermost series of the Mississippian System, is named for Chester, Randolph County, where it is well exposed in the bluffs of the Mississippi River. It was originally called the Kaskaskia Limestone (Hall, 1857) and the *Archimedes* Limestone (Swallow, 1858) before it was named the Chester Limestone. Later it was made the Chester Group, and since 1948 has been the Chesterian Series (J. M. Weller et al., 1948). The Aux Vases Sandstone, long considered to be the base of the Chesterian, is excluded from the series because it is in the *Platycrinites penicillus* Zone near the top of the Valmeyeran Series (Swann, 1963).

The Chesterian Series consists of limestone-shale formations alternating with sandstone-shale formations (fig. M-25). It extends from the major unconformity at the base of the Pennsylvanian System (sub-Absaroka unconformity) down to the base of the Shetlerville Member of the Renault Formation, which is the top of the Valmeyeran Series.

The Chesterian Series occupies much of the southern half of Illinois (fig. M-26). It is a little more than 1400 feet thick in Johnson County in the southern part of the Illinois Basin and thins outward to its truncated edge. The thickness pattern reflects sub-Pennsylvanian valleys that generally run from northeast to southwest and cut into the Chesterian rocks. Chesterian strata crop out in western and southern Illinois from near Valmeyer south to Grand Tower and then eastward through Hardin County to the Ohio River.

The Chesterian Series is subdivided into three stages, the Gasperian (below), Hombergian, and Elviran (Swann, 1963). These units were derived from the New Design, Homberg, and Elvira Groups, which had been used like provincial time-stratigraphic units (figs. M-27 and M-28). The series includes five groups, 20 formations, and 14 members, and it forms the major part of the Pope Mega-group (fig. 14).

Many of the Chesterian limestones and shales are abundantly fossiliferous. The sandstones are much less fossiliferous, but contain

some plant fossils. Coals, a few inches thick at most, occur in some of the Chesterian sandstones. Many of the limestones contain abundant crinoidal fragments, and the series is characterized by the presence of *Talarocrinus*, which distinguishes it from the underlying Valmeyeran containing *Platycrinites penicillus*. Blastoids and the corkscrew bryozoan, *Archimedes*, are common and characteristic (fig. M-4). Several conodont assemblage zones, shown in figure M-25, are useful in differentiating Chesterian rocks (Collinson et al., 1971).

Many of the Chesterian formations have distinctive characters on electric logs (fig. M-29), but the sandstone bodies, although widely traceable, have great lenticularity (fig. M-30).

The clastic sediments in the Chesterian Series were transported by the ancient Michigan River from the northeast and were deposited in deltaic bodies in the marine embayment in the Illinois Basin (Potter, 1962a; Swann, 1963, 1964). The alternation of limestone and sandstone formations resulted from lateral shifts in the mouth of the river and in the position of the shoreline (fig. M-31) during the progressive sinking of the basin (fig. M-32).

On the thickness maps of the Chesterian Series, the eroded margins of the formations from Alton, Madison County, south and east to the Ohio River in Hardin County are largely at the present surface, but the margins trending northeast across the state from the Mississippi Valley are beneath Pennsylvanian strata.

## Gasperian Stage

The Gasperian Stage (Swann, 1963, p. 21-22, 67), the oldest stage of the Chesterian Series, is derived from the Gasper Limestone of Kentucky (Butts, 1917), which is named for the Gasper River, northwest of Bowling Green, Kentucky. It includes rocks from the base of the Shetlerville Member of the Renault Limestone to the top of the Beech Creek Limestone (fig. M-25). The upper part of the Cedar Bluff Group is included in the Gasperian, but the lower part is Valmeyeran and the group was described under Valmeyeran. Sandstone predominates in the Gasperian Stage. In the Anna district of southwestern Illinois, sandstone of the Cypress alone constitutes about half of the Gasperian Stage. In the fluorspar district, where the Gasperian Stage is about 300 feet thick, about 200 feet is sandstone. Marine fossils occur in limestones

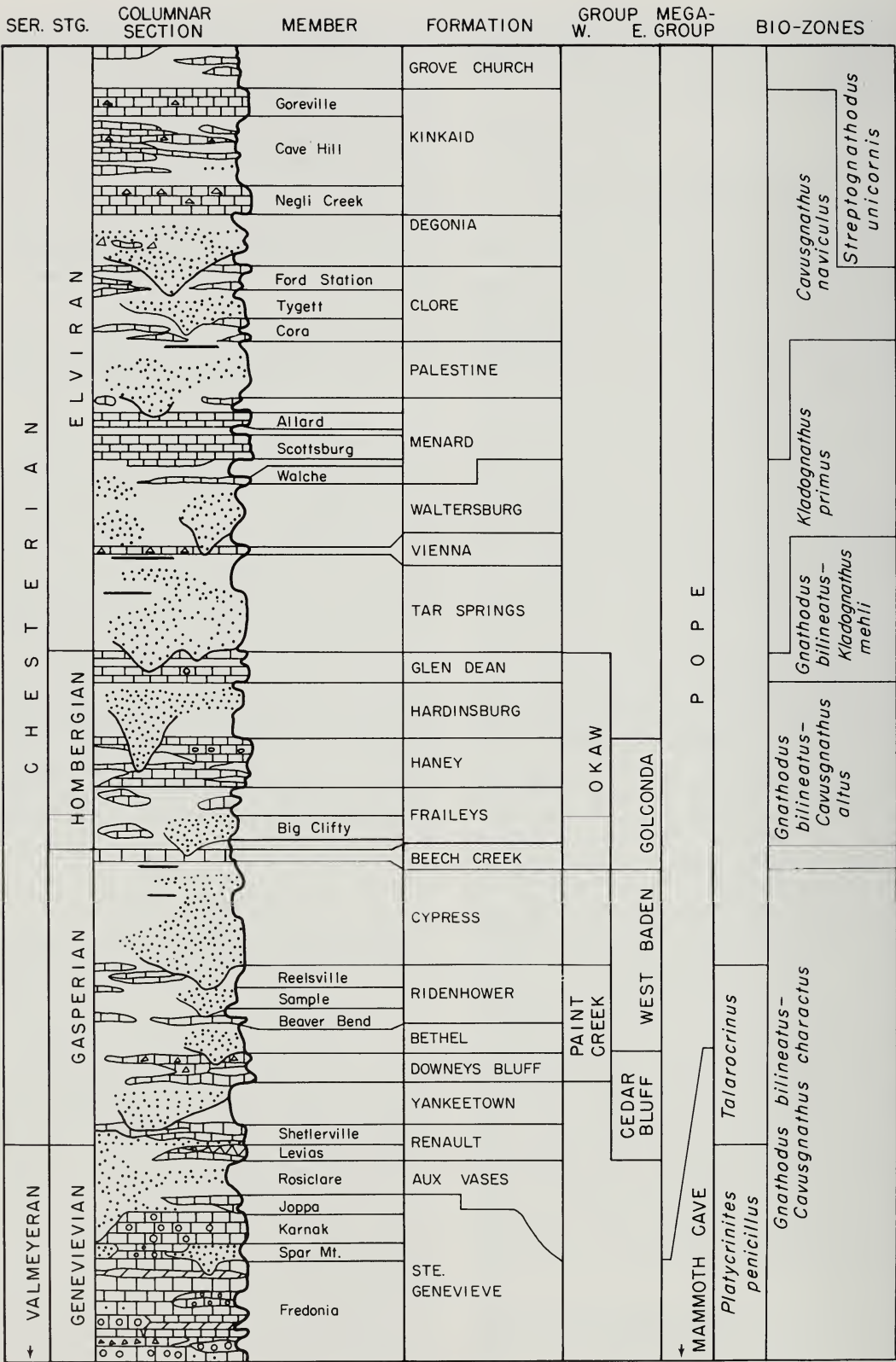


Fig. M-25—Columnar section of the Chesterian Series (after Swann, 1963), showing biozones (after Collinson et al., 1971). In the columnar section, the blank areas are shale.

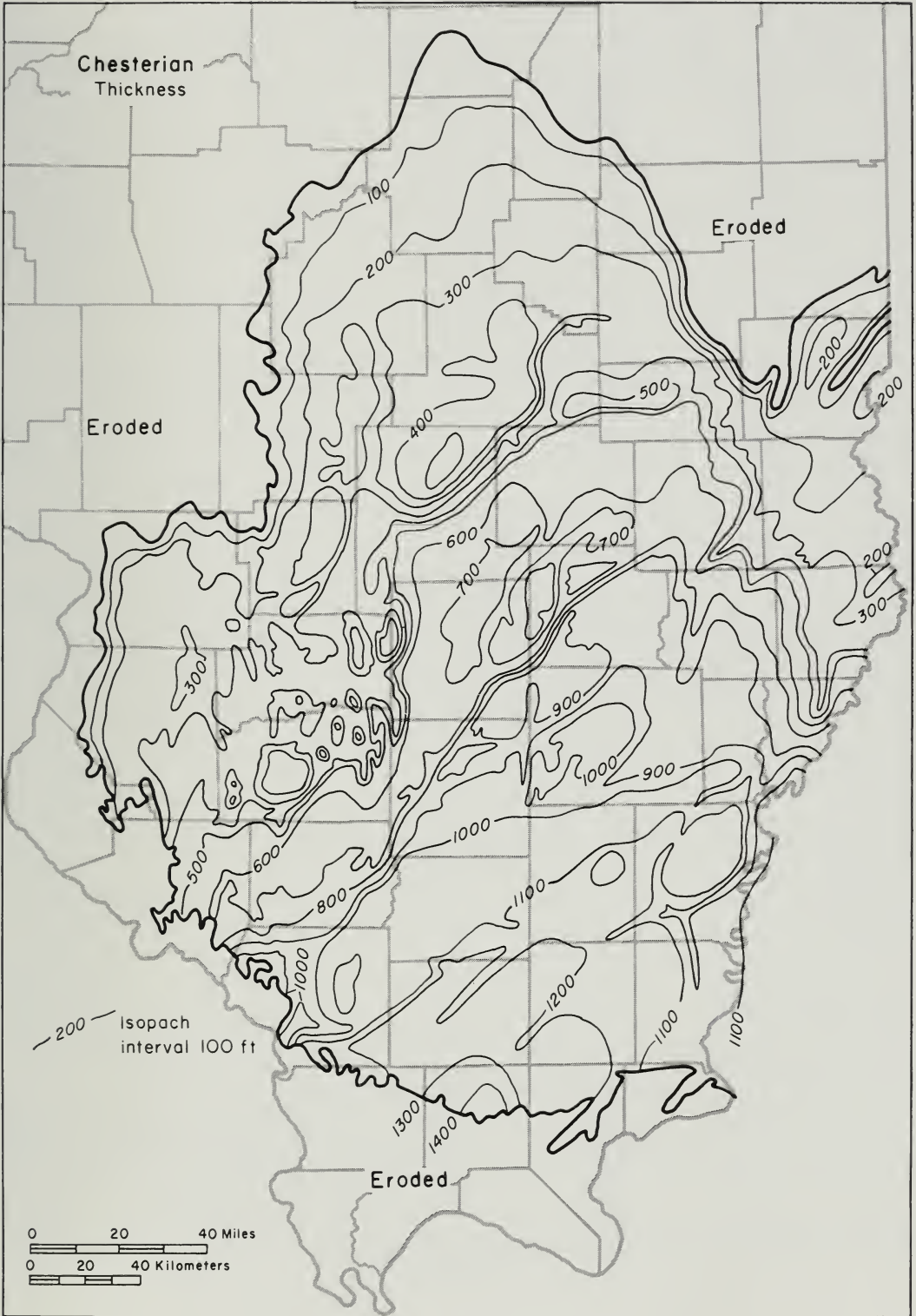


Fig. M-26—Thickness of the Chesterian Series.

Ulrich & Smith 1905		Butts 1917		S.Weller 1920		Sutton & J.M.Weller 1932		J.M.Weller et al. 1952		Swann 1963, Present									
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve Ls.		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia		Rosiclare		Fredonia		Levias		Rosiclare		Upper Fredonia		"Spar Mountain"		Lower Fredonia		Fredonia	
Chester Group		Kaskaskia Limestone		Birds-ville		Tribune		Cypress		Chester Group		Chesterian		Hombergian		Gasperian		Valmeyerian	
Ste. Genevieve		Ohara		Upper Ohara		Lower Ohara		Renault		New Design		Renault		Dawneys Bluff		Shetler-ville		Levias	
Rosiclare		Fredonia																	

Hall 1857	Swallow 1858	Ulrich 1904	S.Weller 1913	Sutton 1934	J.M. Weller 1939	Swann 1963, Present					
Kaskaskia		Birdsville	Clore	Group	Group	Stage					
	Chester					Archimedes Limestone	Chester Group	Chester Series	Chester Series	Grove Church	
										Kinkaid	Kinkaid
										Degania	Degania
										Clore	Clore
										Palestine	Palestine
										Menard	Menard
										Walters- burg	Walters- burg
										Vienna	Vienna
										Tar Springs	Tar Springs
		Glen Dean	Glen Dean								
	Hordins- burg	Hardins- burg									
	Gal- conda	Gal- conda									
	Marigold										
	Rumo	Cypress									
	Point Creek	Point Creek									
	Yankeetawn	Bethel									
	Renault	Renault									
	Brewerville	Aux Vases									
	Ferru- ginous	Ferru- ginous	Cypress			V.	Me	Ste. Gen.	Val.	Gen.	Aux Vases
St. Louis	St. Louis	Ste. Gen.	Ste. Gen.							Ste. Genevieve	

V.= Volmeyer, Vol.= Valmeyeran, Gen.= Genevievian, Me.=Meromec

Fig. M-28—Development of the classification of the Chesterian Series in southwestern Illinois—the Chester District (after Swann, 1963).

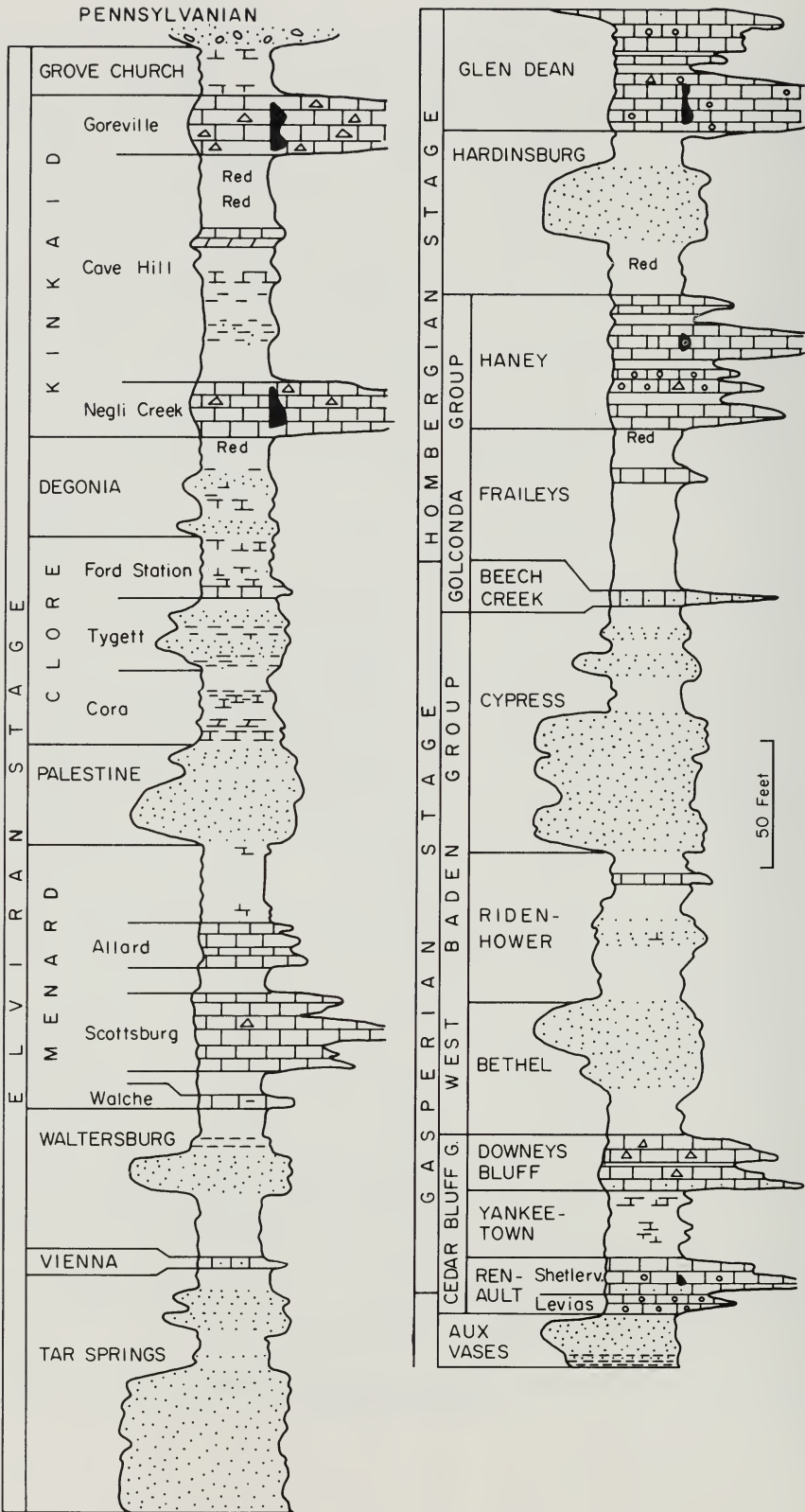


Fig. M-29—Typical electric log of the Chesterian Series.

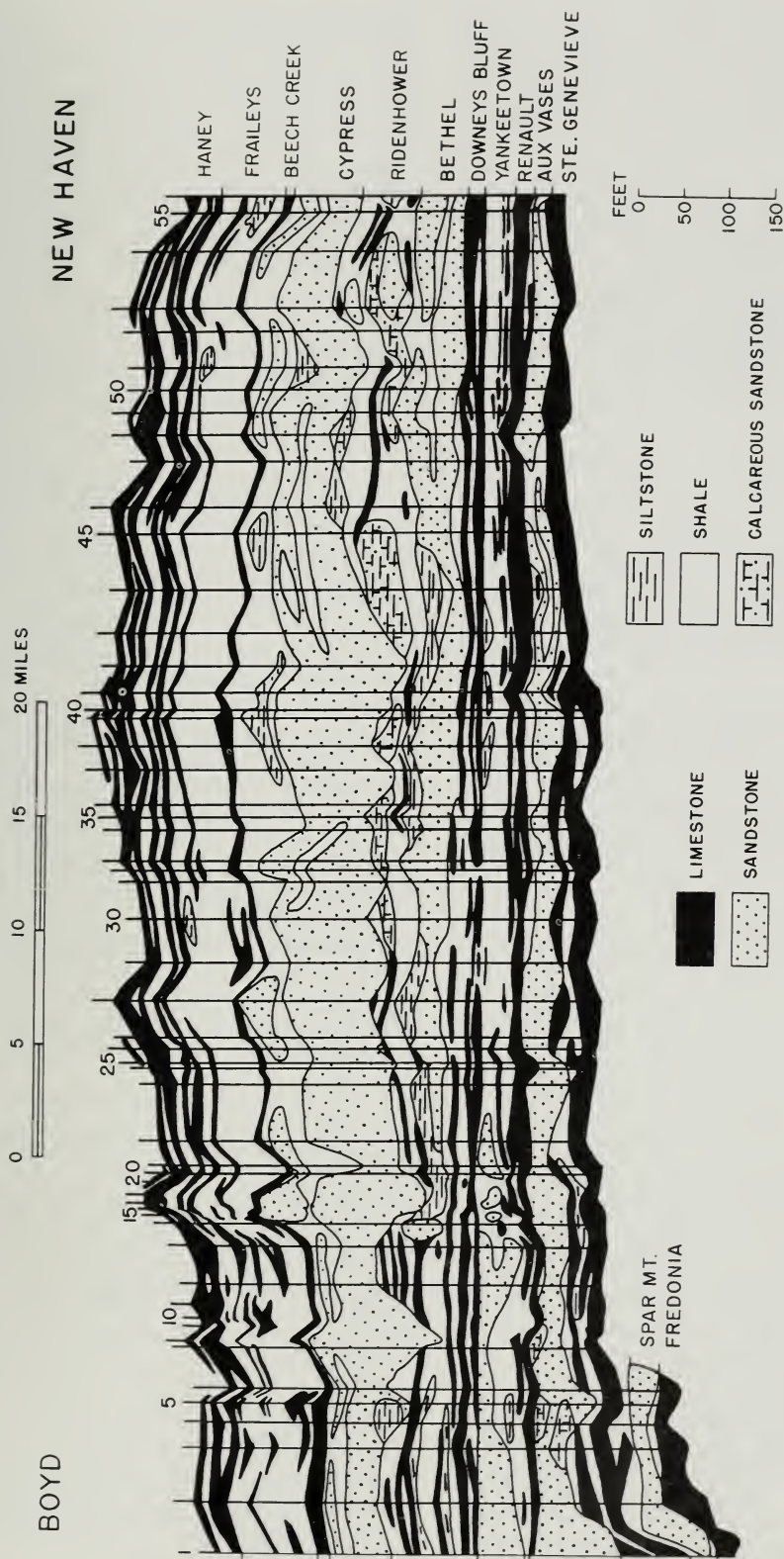


Fig. M-30—Cross section of the lower Chesterian strata between Boyd, Jefferson County, and New Haven, Gallatin County (after Swann and Atherton, 1948).

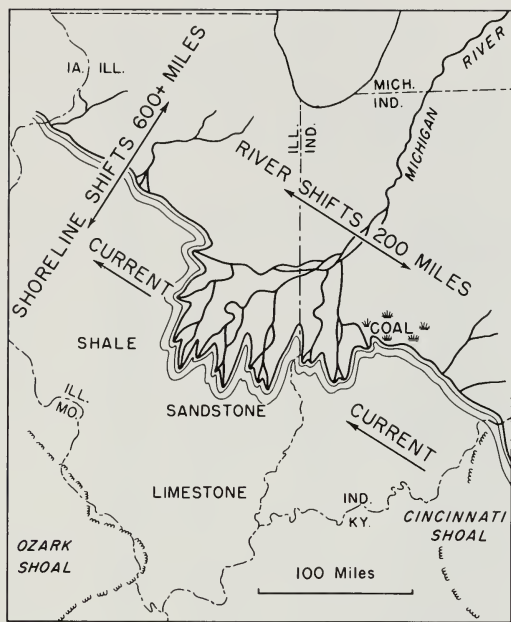


Fig. M-31—Paleogeography at an intermediate stage during Chesterian sedimentation (after Swann, 1963).

and shales of the Paint Creek Group and the Renault Limestone. The bryozoan *Cystodictya labiosa* Zone and the crinoid *Talarocrinus* Range Zone are the most definitive faunal zones of the Gasperian Stage, although the *Talarocrinus* Zone does not include the Beech Creek Limestone.

Yankeetown Sandstone

The Yankeetown Sandstone (S. Weller, 1913, p. 120) is named for Yankeetown School, Monroe County, near which the type section (NE cor. SE 26, 4S-9W) consists of cherty sandstone grading to chert. The Yankeetown is a sandstone-shale unit in western Illinois that grades into a limestone-shale unit in eastern Illinois. Although only about 20 feet thick in the outcrop area, it can be traced northeastward into the upper part of a thick sandstone in Washington County, where it is separated by a thin limestone (Renault) from the Aux Vases Sandstone below. As thus differentiated, the Yankeetown Sandstone includes sandstone and shale formerly regarded as being in the upper part of the Renault. The Yankeetown is about 60 feet thick in much of the central part of its extent (fig. M-33). To the north it thins to less than 20 feet, and to the south and southwest it thickens in places to a little over 100 feet. Red shale is extensively developed near the top of the Yankeetown, but other shales present are dark greenish gray, green, and variegated. The sandstone is much like that in the Bethel, mainly white or light gray to light greenish gray, very fine, angular, and incoherent. Chert occurs only in, and close to, the western outcrop belt. Southeastward the sandstone facies changes to a limestone-shale facies, the change occurring near the north-western corner of Hamilton County (Swann and Atherton,

1948). At about the same place, the Bethel Sandstone, which is predominantly shale to the northwest, becomes predominantly sandstone to the southeast, which misled many into thinking that the Bethel and Yankeetown were equivalent (fig. M-7). The sandstone of the Yankeetown was commonly called "Benoist," and the names "Benoist" and "Bethel" were mistakenly regarded as being interchangeable. In the limestone-shale facies, most of the shales are dark greenish gray and green, with some red in the upper part. The limestones are light gray, buff, brown, or gray. Some are oolitic, some crinoidal, some silty, and some lithographic.

Paint Creek Group

The Paint Creek Group (S. Weller, 1913, p. 120; Swann, 1963, p. 76) is named for Paint Creek, a stream in Randolph County,

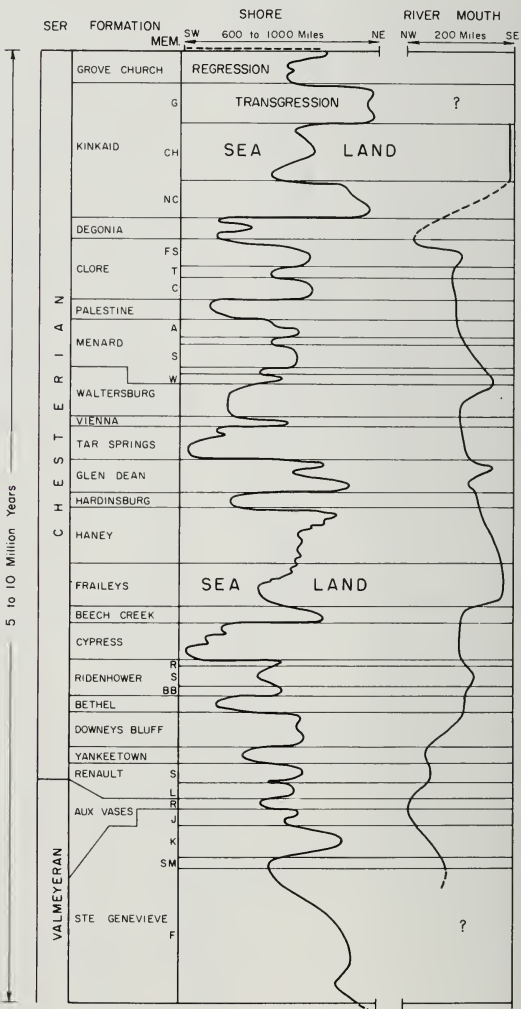


Fig. M-32—Changes in position of the shoreline and the position of the Michigan River during late Valmeyeran and Chesterian times (after Swann, 1963).

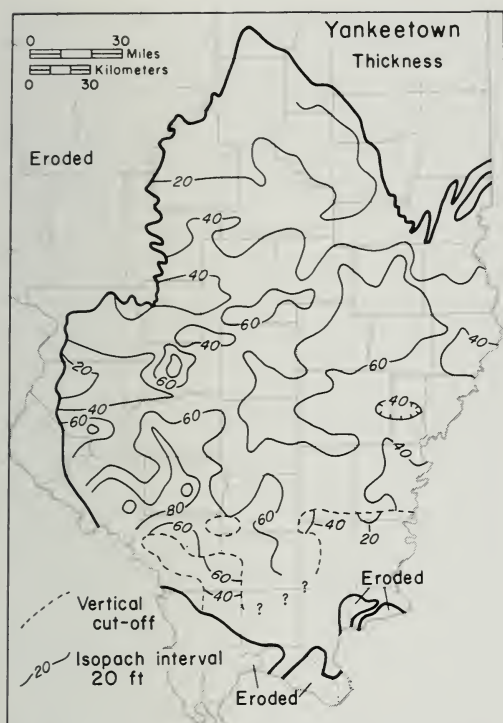


Fig. M-33—Thickness of the Yankeetown Sandstone.

and the type section is along a tributary west of McCuen School (E1/2 2, 5S-9W). It is recognized only in western Illinois, where it is dominantly shale and limestone and consists of the Downeys Bluff, Bethel, and Ridenhower Formations (fig. M-25). Although the Bethel is normally a sandstone, it is shale in that area and includes a bed of bright red shale. The name was formerly used in southeastern Illinois for the strata now included in the Ridenhower Formation.

### Downeys Bluff Limestone

The Downeys Bluff Limestone (Atherton, 1947, p. 129) is named for Downeys Bluff, Hardin County, and the type section is in a bluff along the Ohio River (NW SE 5, 13S-8E). It was originally regarded as a member of the Paint Creek Formation in southwestern Illinois and of the Renault Formation in southeastern Illinois, but it was later traced across the Illinois Basin (Dana and Scobey, 1941). It is now a formation at the base of the Paint Creek Group in southwestern Illinois and at the top of the Cedar Bluff Group in southeastern Illinois (fig. M-25). The Downeys Bluff generally is 20-30 feet thick in Gallatin, Saline, and parts of Jackson and adjacent counties (fig. M-34), where it consists of two limestone benches separated by a thin shale. Elsewhere the Downeys Bluff consists of only the upper of the two benches, generally 5-10 feet thick but locally 10-20 feet thick. Where two benches of the Downeys Bluff are present, the upper is typically cherty and the lower is slightly silty or very

finely sandy. Limestone of the Downeys Bluff is white or light brownish gray and crinoidal. Many crinoid segments are replaced by pink chert. The pink crinoids are an excellent diagnostic characteristic that is better developed in the western than in the eastern part of Illinois.

### West Baden Group

The West Baden Group (Cumings, 1922, p. 514; Gray et al., 1960, p. 44) is named for West Baden, Orange County, Indiana, and consists of the Bethel, Ridenhower, and Cypress Formations. It occurs in southeastern Illinois and is most useful in an area where the Ridenhower is dominantly sandstone and separation of the formations is difficult—in places impractical (Swann, 1963).

### Bethel Sandstone

The Bethel Sandstone (Butts, 1917, p. 63-64) is named for Bethel School, 3.5 miles west of Marion, Crittenden County, Kentucky. It is dominantly sandstone in much of Illinois, but it grades to shale to the west. The Bethel is 20-40 feet thick in much of its northwestern area (fig. M-35), but locally it is thinned by pre-Cypress erosion. The formation thickens to the southeast, reaching just over 100 feet in eastern Gallatin County. The sandstone of the Bethel is, in general, the coarsest grained of the Chesterian sandstones. Locally, it includes a few small quartz pebbles and a basal conglomerate of limestone and shale pebbles. Most of the sandstone is light gray to light

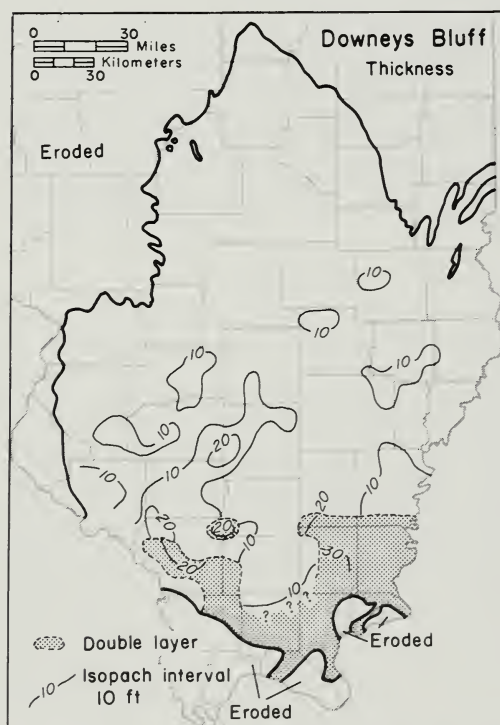


Fig. M-34—Thickness of the Downeys Bluff Limestone.

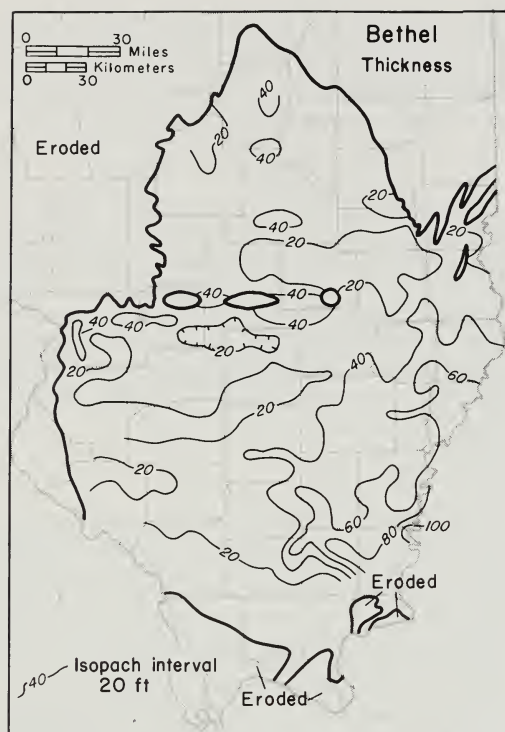


Fig. M-35—Thickness of the Bethel Sandstone.

greenish gray, but a few thin lenses are green or medium gray. Dark greenish gray shale partings are common, and some contain carbon and mica flakes. As the sandstone grades westward to shale, red and green shales become more noticeable. Along the outcrop belt in southwestern Illinois, a persistent bed of deep red, structureless clay about 15 feet thick is prominent. In places, numerous fragmentary plant fossils, including *Lepidodendron*, are present.

### Ridenhower Formation

The Ridenhower Formation (Butts, 1917, p. 73) is named for Ridenhower School, Johnson County, and the type section is at Indian Point, 5 miles south of Vienna (SE SW 32, 13S-3E), where the formation is 60 feet thick and consists of shale with beds of fossiliferous limestone. The formation is a markedly varied unit that is mainly shale but contains beds of limestone and sandstone. It occurs between two clastic formations, dominantly sandstone. Locally, in parts of central and eastern Illinois, the formation is subdivided into the Beaver Bend Limestone Member (below), the Sample Sandstone Member, and the Reelsville Limestone Member, but in most of Illinois these units cannot be differentiated. They are well developed in Indiana and Kentucky, where they were named. The average thickness of the Ridenhower Formation in southern Illinois is about 33 feet, but at several places it is more than 80 feet thick (fig. M-36). The contact of the Ridenhower with the overlying Cypress Sandstone is generally sharp. In some places the Riden-

hower is absent and the Cypress rests on the Bethel Sandstone. The shale of the Ridenhower is mainly dark greenish gray, but red, green, and brown shales are common. Much of the shale is calcareous and fossiliferous. The limestone includes sandy, oolitic, crinoidal, and lithographic beds, most of which are light to dark gray and brown, but buff, green, pink, and yellow beds are present. Some distinctive beds can be traced for several tens of miles. The proportion of limestone in the formation increases westward, so that near its western limit the formation is almost all limestone. In contrast, the proportion of sandstone is greatest in southeastern Illinois from Hardin County north-northeast along the Wabash River. The fauna of the Ridenhower resembles that of the Renault. The bryozoans *Cystodictya* and *Archimedes* and the blastoid *Pentremites* are common.

**Beaver Bend Limestone Member**—The Beaver Bend Limestone Member of the Ridenhower Formation (Malott, 1919, p. 9-10), the lowermost member, is named for a prominent bend in Beaver Creek, Lawrence County, Indiana, and the type section is a railroad cut half a mile east of Huron. The Beaver Bend is classified as a formation in Indiana. It consists of limestone and shale, and in southeastern Illinois it can be differentiated from the Reelsville Member only locally, where the intervening Sample Sandstone is present.

**Sample Sandstone Member**—The Sample Sandstone Member of the Ridenhower Formation (Butts, 1917, p. 70-73), the middle member, is named for the town of Sample, Breckenridge County, Kentucky, and the type section is in a railroad cut on the north bank of Sinking Creek, 1 mile east of Sample. The Sample Sandstone Member is dominantly sandstone and shale. It occurs locally in southeastern Illinois.

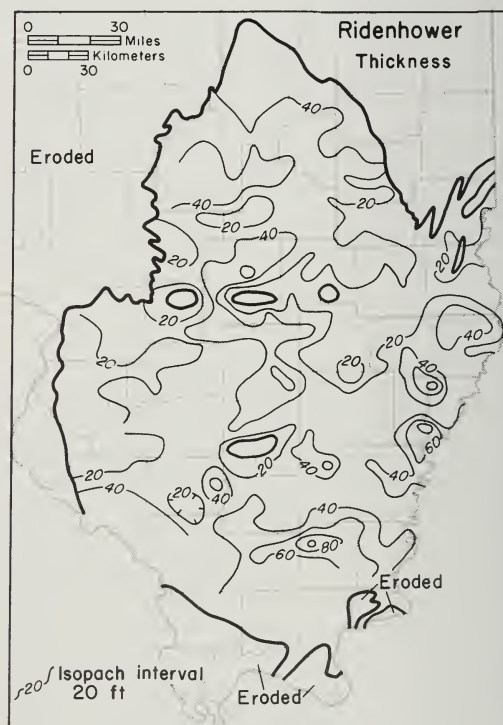


Fig. M-36—Thickness of the Ridenhower Formation.

**Reelsville Limestone Member**—The Reelsville Limestone Member of the Ridenhower Formation (Malott, 1919, p. 10-11), the uppermost member, is named for Reelsville, Putnam County, Indiana, and the type section is on the Eel River, just south of Reelsville, where the member is 2.5 feet thick. It is classified as a formation in Indiana. It is dominantly limestone but contains beds of shale. It is not differentiated in the type section of the Ridenhower Formation, and it has limited distribution in southeastern Illinois, mostly in subsurface. The *Agassizocrinus* cf. *leavis* Peak Zone is equivalent to the Reelsville Member.

## Cypress Sandstone

The Cypress Sandstone (Engelmann, 1863, p. 189-190) is named for Cypress Creek, Union County, and the type section is in bluffs along the creek about 6 miles southeast of Anna (T12 and 13S-1E). The name Ruma, now abandoned, was given to equivalent strata in Randolph County (S. Weller, 1913). The Cypress and the Tar Springs Sandstone are the thickest and most persistent sandstone formations of the Chesterian Series. In the central part of southern Illinois, the Cypress is generally well over 100 feet thick, and it reaches 200 feet thick (fig. M-37). It thins outward from that area, and it is only 20-30 feet thick near the outcrops in southern Randolph County. It varies from thick bodies of sandstone to shale and sandy shale interbedded with some thin beds of sandstone. The massive sandstone in the Cypress is white to light gray, fine to medium grained, angular, and generally friable. It makes up about half of the formation and typically is in a single body at the base of the formation. Some wells encounter two sandstone bodies, usually in

the lower part of the formation, and others, mostly in the north and southwest but sporadically elsewhere, encounter only shale. Typically the upper part of the Cypress is more shaly than the lower, and commonly 5-30 feet of shale or sandy shale occurs at the top. Locally a few thin beds of sandstone lie immediately below the overlying Beech Creek Limestone. Sandstone beds near the top are generally cemented with calcite or dolomite. The shale in the Cypress is largely dark greenish gray, but some of the top beds are green, and a moderately persistent bed of red shale occurs about 10 feet below the top of the formation. In Randolph County in western Illinois, where the Cypress is almost entirely shale, the formation includes a considerable proportion of red and green shale. Beds of gray or green siltstone are present in the upper part of the Cypress, and a thin, dark green, quartzitic siltstone occurs near the top. Coal beds a few inches thick are sporadically present near the top of the Cypress, especially near its southern limit. The base of the Cypress and, to a lesser extent, surfaces in the middle part of the formation tend to parallel underlying structure more closely than they do the overlying Beech Creek Limestone, which suggests slight warping during Cypress time. Plant fossils, including *Lepidodendron* trunks, are present in the Cypress.

## Golconda Group

The Golconda Group (Brokaw, 1916, pl. 3; Ulrich, *in* Butts, 1917, p. 91-95; Swann, 1963, p. 68) is named for Golconda, Pope County, and the type section is in the bluffs of the Ohio River above Golconda (secs. 5, 8, 18, 13S-7E). It is a limestone-shale unit, but it has a sandstone member locally present in its lower part in the northeastern part of its area. It consists of the Beech Creek Limestone at the base, the Fraileys Shale, and the Haney Limestone (fig. M-25). The Golconda Group ranges from about 60 feet thick near its northern limit to over 180 feet near its southern limit.

## Okaw Group

The Okaw Group (S. Weller, 1913, p. 120; S. Weller and J. M. Weller, 1939, p. 12; Swann, 1963, p. 76) is named for the Okaw River, now the Kaskaskia River, and the type section consists of exposures along the river in Randolph County (T4, 5, and 6S, R7 and 8W). The name is used only in western Illinois for formations from the Beech Creek through the Glen Dean (fig. M-25) in an area where the clastic units of the Hardinsburg are poorly developed and it is difficult to assign many small limestone outcrops to the proper formation.

## Beech Creek Limestone

The Beech Creek Limestone (Malott, 1919, p. 11-15) is named for Beech Creek, Greene County, Indiana, and

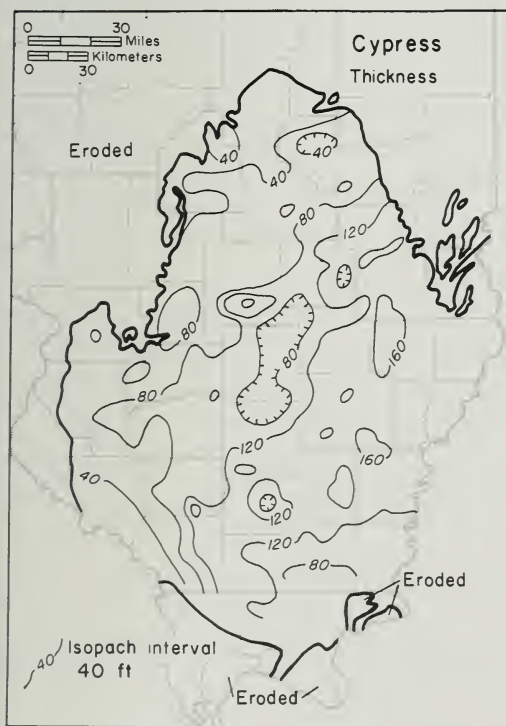


Fig. M-37—Thickness of the Cypress Sandstone.

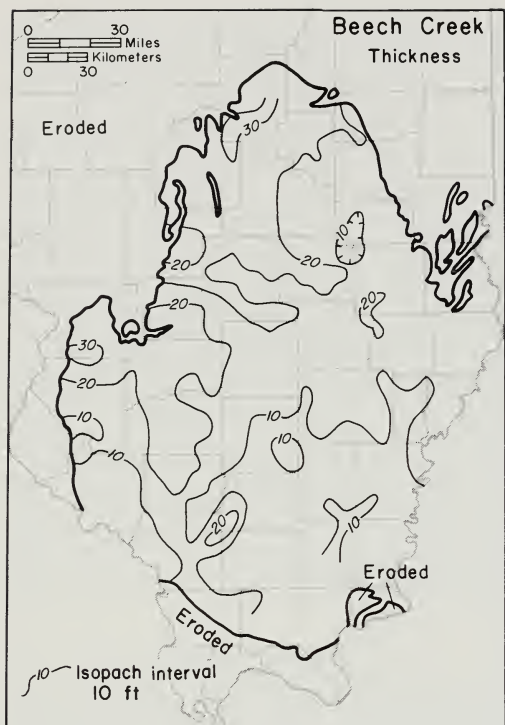


Fig. M-38—Thickness of the Beech Creek Limestone.

the type section is at the mouth of Ray's Cave, one-fourth of a mile south of Beech Creek. It is a relatively thin limestone unit, commonly called the "Barlow lime." It is very persistent and is widely used as a horizon for structure contour maps of the Illinois Basin (Bristol, 1968). The Beech Creek is unusual in that it thickens from south to north, counter to the trend of other Chesterian formations (fig. M-38). It is as much as 35-40 feet thick in the north but in areas in Hardin County it is thin, shaly, and difficult to identify. In some places the changes in thickness are abrupt and probably result from fusion of the formation with limestone beds that elsewhere are in the lower part of the Fraileys Shale. The lower part of the Beech Creek is argillaceous, dark brownish gray, dense to lithographic limestone, usually with scattered, black, rounded grains and a few fossils. The upper part is light brownish gray, fine to coarse grained, fossiliferous, and similar to much of the limestone higher in the Golconda Group. Some thin beds of oolitic limestone are present. The Beech Creek becomes somewhat sandy eastward, and in the vicinity of Saline and southern Hamilton Counties it seems to be represented locally by a bed of calcareous sandstone. *Euphemia randolphensis*, a pelecypod, and *Martinia contracta*, a brachiopod, are characteristic of some beds in the Beech Creek.

### Hombergian Stage

The Hombergian Stage (Swann, 1963, p. 22, 70), the middle stage of the Chesterian Series, derived from the Homberg Group

(J. M. Weller, 1939), is named for Homberg, Pope County. The Hombergian Stage includes strata from the top of the Beech Creek up to the top of the Glen Dean (fig. M-25). The limestones in this stage are typically light brownish gray, light gray, or buff to gray and many of them and their associated shales are abundantly fossiliferous. Red shales in the upper part of the Fraileys and the lower part of the Hardinsburg are extensive marker beds. The bryozoan *Prismopora serrulata* and the crinoid *Pterotocrinus* (fig. M-4) are typical Hombergian fossils.

### Fraileys Shale

The Fraileys Shale (McFarlan et al., 1955, p. 18) is named for Fraileys Landing (abandoned), Hardin County, about a mile northeast of the type section in a bluff along Haney Creek (NE NE SE 9, 12S-10E), where the formation is 94 feet thick. It is dominantly shale, with minor amounts of limestone and, locally, sandstone. The Fraileys Shale is 80-100 feet thick in most of Williamson County, and it thins irregularly northward to 30-40 feet in the northern and northeastern areas (fig. M-39). Great variations in thickness within short distances have a reciprocal relation with units above and below. The Fraileys is dominantly dark gray shale. A bed of red shale a few feet below the top and a bed of siltstone just below the shale are persistent in the southern area. Limestone beds occur sporadically at numerous levels. A bed about 15 feet below the top is fairly persistent, but the others, mostly lenticular accumulations of fossil debris, thin rapidly and disappear within a short distance. Some of these beds



Fig. M-39—Thickness of the Fraileys Shale.

contain abundant fragments of bright red, orange, and green fossils, mainly bryozoans but also a few oolites and other detrital grains. In the north, limestone is fairly abundant locally in the Fraileys, particularly in the lower part, and in places it is difficult to distinguish limestone at the base of the Fraileys from the underlying Beech Creek Limestone. Sandstone in the Fraileys, where present in significant amount, is assigned to the Big Clifty Sandstone Member. The corkscrew-like axes of the bryozoan *Archimedes* reach a peak in number of species and abundance of specimens in the Fraileys and Haney Formations. A brachiopod faunal zone, the "*Camarophoria*"—*Stenosisma explanata* Range Zone, extends from the Fraileys upward to the top of the Chesterian strata. The *Pterotocrinus capitalis* Range Zone is equivalent to the lower half of the Fraileys Shale.

**Big Clifty Sandstone Member**—The Big Clifty Sandstone Member of the Fraileys Shale (Norwood, 1876, p. 405) is named for Big Clifty Creek, Grayson County, Kentucky, and the type section is along the creek, 2 miles southwest of the village of Big Clifty. The Big Clifty enters Illinois from the east and wedges out within a few tens of miles. Many wells in Lawrence, northern and eastern Jasper, and southern Cumberland Counties encounter 15-20 feet of Big Clifty. It is near the middle of the Fraileys or, less commonly, near the base. A few sporadic occurrences have been found in Marion County and east of there. In Indiana the Big Clifty occupies nearly the whole of the interval represented by the Fraileys Shale in Illinois.

### Haney Limestone

The Haney Limestone (McFarlan et al., 1955, p. 18) is named for Haney Creek, Hardin County. It is 35.5 feet thick in the type section, which overlies the type section of the Fraileys Shale (NE NE SE 9, 12S-10E). It is dominantly limestone, with a little interbedded shale. The formation thickens from north to south (fig. M-40). It is

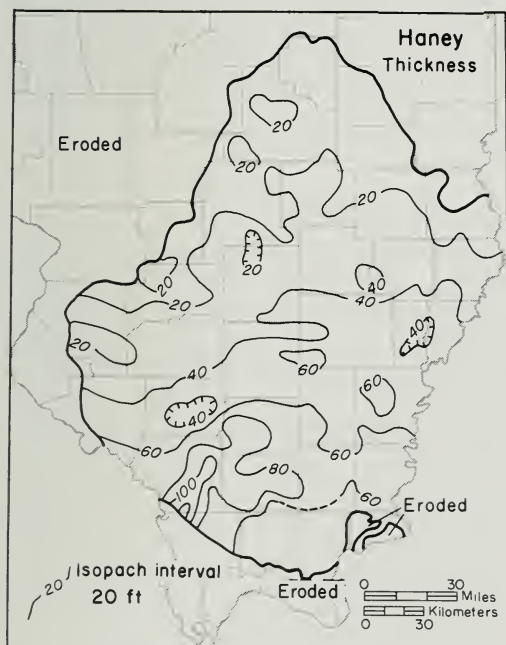


Fig. M-40—Thickness of the Haney Limestone.

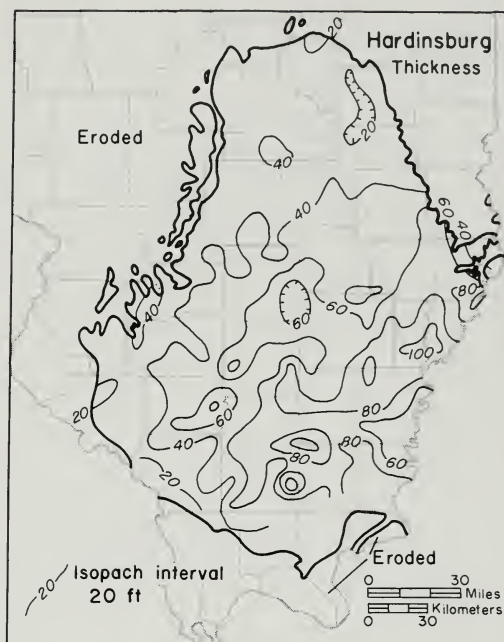


Fig. M-41—Thickness of the Hardinsburg Sandstone.

80-100 feet thick in much of Williamson County and even thicker in southern Jackson County, but it generally thins to less than 15 feet thick in Moultrie, Coles, and Cumberland Counties. In Washington County, the lower part of the Haney grades northwestward to shale, and the base of the Haney shifts to a higher horizon—the formation thinning from 60 feet or more to 35-40 feet. The limestone of the Haney is typically light gray to brownish gray or dark gray, coarse grained, and fossiliferous. Much of it is oolitic. In Randolph County a zone of white oolite about 20 feet thick in the Haney is informally called the "Marigold Oolite" (Sutton, 1934) for the village of Marigold, near which it is well exposed (SE 20, 5S-8W). In many places the oolitic beds alternate with non-oolitic beds or with shale. A little chert is commonly present in the Haney, and much of the limestone is shaly. The shale is dark gray and generally calcareous and fossiliferous. The individual limestone beds generally are markedly lenticular and are much less persistent laterally than are beds in the younger Chesterian limestones. In the southern part of the area, the Haney is characterized by an upper limestone unit about 25 feet thick, a middle shale up to 10 feet thick, and a lower limestone about 50 feet thick, the upper part of which is more shaly than the lower. To the northwest the Haney grades to a shale that cannot be readily distinguished from the overlying shale of the Hardinsburg or the underlying Fraileys.

### Hardinsburg Sandstone

The Hardinsburg Sandstone (Brokaw, 1916, pl. 3; Butts, 1917, p. 23) is named for Hardinsburg, Breckenridge County, Kentucky, and it is 30 feet thick in the type section, which is near the town. It is a clastic unit commonly 50-100 feet thick but thinner to the north and west (fig. M-41). In Lawrence County, the Hardinsburg

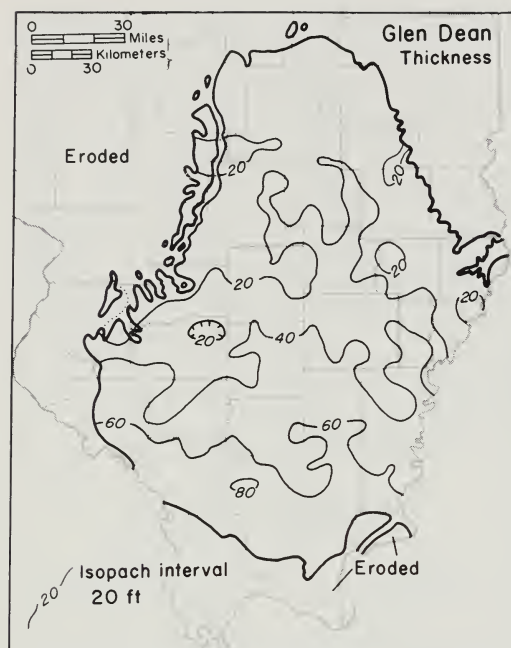


Fig. M-42—Thickness of the Glen Dean Limestone.

locally cuts entirely through the underlying Golconda Group and into the uppermost part of the Cypress Sandstone to attain a thickness of more than 240 feet. The formation has a thick-bedded sandstone facies and a thin-bedded, flaggy, shaly sandstone and shale facies, both exposed in the southern outcrop belt. Well developed sandstone bodies lens in and out of the section within fairly short distances at various horizons and locally make up almost the entire formation. The sandstone in the Hardinsburg is largely light gray, very fine grained, friable, and in part calcareous. The thick sandstone bodies are white and fine grained, whereas the thin bodies are generally gray or green and compact, some of them grading to siltstone. The sandstone bodies show a complex deltaic pattern with braids, tributaries, and distributaries (Potter, 1963). Much of the system is to the east in Indiana and Kentucky, but bifurcating arms extend into Illinois. Thin beds of coal occur locally in the upper part of the sandstone. The shale in the Hardinsburg is mainly dark gray or dark greenish gray. At the base of the Hardinsburg, red, green, and dark gray shale as much as 30 feet thick contains beds and nodules of lithographic, red and brown limestone and dolomite. In most places an erosional surface separates the shale from the upper part of the Hardinsburg, and in some places the surface cuts entirely through the shale, so that sandstone rests directly on the underlying Golconda Group.

### Glen Dean Limestone

The Glen Dean Limestone (Butts, 1917, p. 97-102) is named for the town of Glen Dean, Breckenridge County, Kentucky, and the type section is in exposures along a railroad (abandoned) on both sides of the town. The Glen Dean is a limestone-shale unit that thickens from 5-15 feet in the north to 65-80 feet in the south (fig. M-42). In

subsurface the top and base of the Glen Dean are put at the limits of well defined limestone strata. In the south, the Glen Dean typically has a threefold division into upper and lower limestone units separated by shale. In a few places a shale lens occurs in the lower limestone. Farther north only the lower limestone unit is generally present, and the formation is correspondingly thinner. In general, where the Glen Dean is relatively thick it contains a higher proportion of shale. The Glen Dean has fairly rapid lateral variations in thickness and in limestone-shale ratio, particularly in the upper two units, and boundaries between the subdivisions are not consistent throughout large areas. The Glen Dean is composed of limestone and various amounts of dolomite and shale. The limestone is light to medium brownish gray, coarse grained, and fossiliferous. Parts of it are oolitic and some beds are cherty. Well developed oolitic limestone is rare in younger Chesterian limestones. The shales are dark greenish gray and are generally fossiliferous. The bryozoan *Prismopora serrulata* is abundant and the blastoid *Pentremites spicatus* is also characteristic of the Glen Dean. The *Pterotocrinus acutus*-*P. bifurcatus* Assemblage Zone is equivalent to the Glen Dean.

### Elviran Stage

The Elviran Stage (Swann, 1963, p. 23, 65), the youngest stage of the Chesterian Series, originally called the Elvira Group (J. M. Weller, 1939), is named for Elvira Township, Johnson County (12S-2E). It includes the nine formations younger than the Glen Dean Limestone (fig. M-25). The limestones of the Elviran Stage are generally darker and finer grained and contain more silt and argillaceous material and less abundant fossils than the older Chesterian limestones. Representative fossils include *Pentremites fohsi*, *Pterotocrinus menardensis*, *Composita subquadrata*, *Eumetria costata*, and *Sulcatopinna missouriensis*.

### Tar Springs Sandstone

The Tar Springs Sandstone (Owen, 1856, p. 174; Butts, 1917, p. 103-105) is named for Tar Springs, Breckenridge County, Kentucky, and the type section is an exposure in a cliff at the town, where the sandstone is about 50 feet thick. It is one of the thickest and most persistent sandstone formations of the Chesterian Series. The Tar Springs is 75-130 feet thick for most of its extent in Illinois, thinning to about 50 feet near its northwestern limits (fig. M-43). It is locally more than 150 feet thick, and in the thicker portions the ratio of sandstone to shale is relatively high. Locally the formation is almost entirely sandstone or almost entirely shale (fig. M-1A). The sandstone is white to light gray, very fine grained to fine grained, locally medium grained, angular, and friable to well cemented. Conglomerate with coarse sand grains and limestone pebbles occurs at the base but is rare. In general, one to three well developed sandstone bodies make up a little more than half the formation. Commonly, a sandstone body occurs at the base of the formation, but sand-

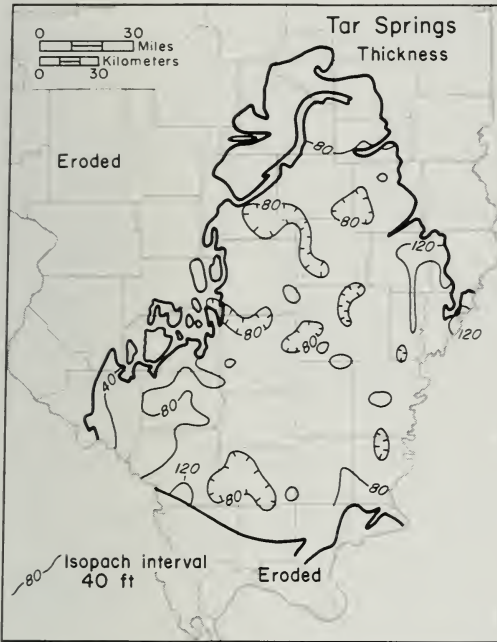


Fig. M-43—Thickness of the Tar Springs Sandstone.

stones also occur at the middle and at the top. The sandstone bodies in the Tar Springs thicken or thin rapidly, and they have a deltaic distributary pattern similar to that of other Chesterian sandstones (Swann, 1963). The remainder of the formation is shale, siltstone, and shaly sandstone. The shale is dark gray and slightly carbonaceous. The siltstones and some of the thin-bedded sandstones are medium to dark olive gray. Commonly there is 3-15 feet of shale at the base and a little more than that at the top. Thin beds of coal occur locally near the top and middle of the formation, especially near the southern limit.

### Vienna Limestone

The Vienna Limestone (S. Weller, 1920, p. 396-398) is named for Vienna, Johnson County, and the type section is in an old quarry west of the town (NE SW NW 5, 13S-3E), where the formation is 14 feet thick. It is a thin limestone, rarely more than about 8 feet thick and commonly only 3 or 4 feet (fig. M-44). However, in extreme southern Illinois the limestone thickens rapidly to 30 feet (fig. M-1A). Until recently, the calcareous shale locally present above and below the limestone bed was assigned to the Vienna (Swann, 1963). The limestone is mainly dark brownish gray, but some is brown or dark gray. It is generally very fossiliferous, with crinoid fragments predominating. It contains dark chocolate-brown chert nodules in the outcrop, but chert is rare in subsurface. Locally some beds are sandy. In places thin beds and partings of shale are interbedded with the limestone. The fauna includes the bryozoan *Prismopora serrulata*, which is also abundant in the Glen Dean, and the pelecypod *Sulcatopinna missouriensis*, which is abundant in the Menard.

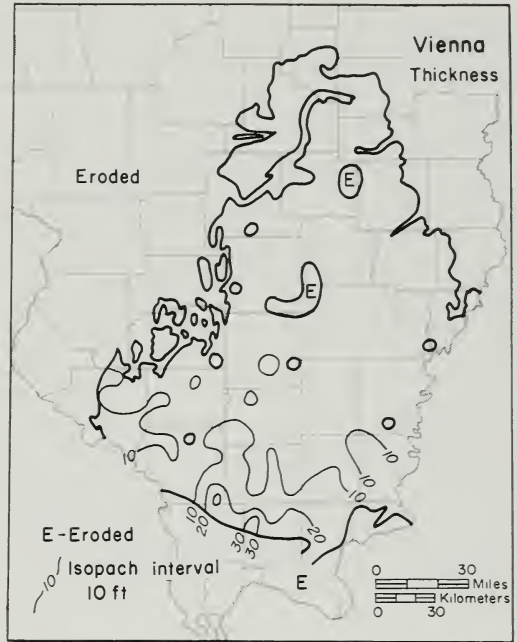


Fig. M-44—Thickness of the Vienna Limestone.

### Waltersburg Formation

The Waltersburg Formation (S. Weller, 1920, p. 398) is named for Waltersburg, Pope County, which is near the type section (SE cor. 17, 13S-6E). It is a clastic unit consisting mainly of shale, but it has beds of siltstone and

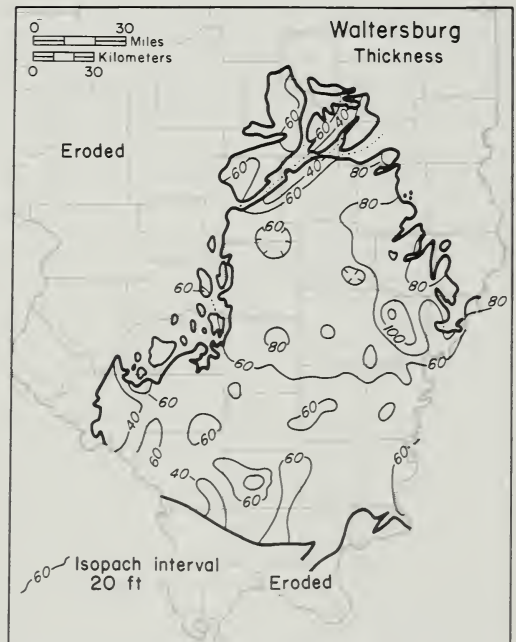


Fig. M-45—Thickness of the Waltersburg Sandstone.

sandstone. The Waltersburg is 50-75 feet thick throughout most of Illinois (fig. M-45), but it thins to about 30 feet to the west in Randolph County and thickens to 80-100 feet to the northeast in Jasper and Richland Counties. The thickness increases at the edge of the Walche Member at the base of the Menard, where the top of the Waltersburg steps up from the base of the Walche to the base of the Scottsburg Limestone Member. The Waltersburg Formation is mainly dark gray, slightly carbonaceous shale, in part silty and sandy. Green shale occurs in the upper part of the Waltersburg, and a thin coal is present near the top of the formation close to its southern edge. In the south, some of the shale at the top and bottom of the formation is calcareous and fossiliferous, and until recently it was assigned to the Menard above or the Vienna below (Swann, 1963). The Waltersburg includes beds and laminae of dark gray and dark olive siltstone and beds of gray to white sandstone that is very fine to fine grained, locally quartzitic, and characteristically well jointed. Most of the thick sandstone bodies in the Waltersburg are within 30 miles of the Wabash River (Swann, 1951; Potter, 1963), are strongly linear, and trend northeast-southwest. They are well exposed on Bay Creek between Simpson and Grantsburg, near the Pope-Johnson county line.

## Menard Limestone

The Menard Limestone (S. Weller, 1913, p. 120, 128) is named for Menard, Randolph County, where the type section is in the quarry at the Menard State Hospital (NE 23, 7S-7W). The formation is also well exposed in the Mississippi River bluffs at Menard and from Chester to Rockwood, Randolph County. It is a limestone-shale formation, generally 100-150 feet thick in the southern area, 80-100 feet in the central part, and 45-60 feet in the northern and northwestern area, beyond which it is truncated by pre-Pennsylvanian erosion (fig. M-46). The Menard is readily divisible into three limestone members—the Walche (below), the Scottsburg, and the Allard—which are separated by unnamed shale members; a third shale occurs at the top. The limestone of the Menard is argillaceous, dark brownish gray to brown and buff, dense, and fine grained to lithographic. Some beds are oolitic, and many beds contain fine to coarse, dark, rounded grains that give the rock a characteristic speckled aspect. The limestone members are more or less shaly, and they include beds of shale as thick as 5 feet. Chert is present in some places. The shale of the Menard Formation is calcareous, dark gray, and fossiliferous, and it contains thin beds and nodules of limestone. The shale between the Walche and Scottsburg Limestone Members is 3-10 feet thick in most of the area underlain by the Walche Member, beyond which it is not recognized. It thickens in the northeast to about 20 feet or more in Wabash County. The shale between the Scottsburg and Allard Limestone Members is 30-40 feet thick in the far south and thins to about 5 feet in the north. Beds of green shale and green dolomite occur in this unit, and in the south a limestone about 10 feet thick is present in the lower half. The shale at the top of the Menard is generally 20-30 feet thick in the southern part of its extent and 10-20 feet in the northern part. It includes, at the top, a bed of limestone about 5 feet thick. This bed is persistent south of about T6S, but it is generally very thin or absent

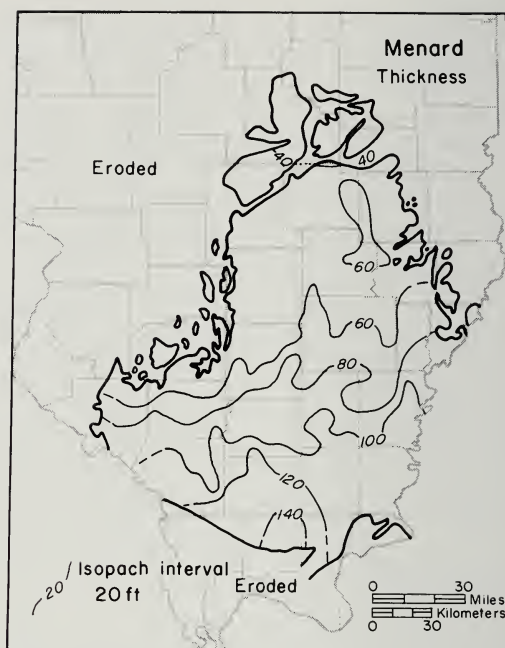


Fig. M-46—Thickness of the Menard Limestone.

farther north. Locally, especially in the north, the erosional surface at the base of the Palestine cuts into the shale and in places entirely through it. The initial appearance of *Spirifer increbescens* and *Composita subquadrata* is in the Menard (S. Weller, 1920). The pelecypod *Sulcatopinna missouriensis* is very abundant in places. The *Pentremites fohsi* Range Zone occurs in the lower part of the Menard (S. Weller, 1926).

**Walche Limestone Member**—The Walche Limestone Member of the Menard Formation (Swann, 1963, p. 38-39) is named for Walche's cut on the Illinois Central Railroad in Caldwell County, Kentucky, where the type section is exposed. Previously it was called the "Little Menard." It is 3-9 feet thick, generally gray to dark gray limestone, typically silty or sandy, and pyritic in part. The Walche is overlapped by the Scottsburg Member, and it is not recognized north of a curve running approximately from northern Wabash County through Wayne County to southwestern Franklin County, beyond which it appears to grade laterally into siltstone that is included in the Waltersburg Formation.

**Scottsburg Limestone Member**—The Scottsburg Limestone Member of the Menard Formation (Swann, 1963, p. 38-39) is named for Scottsburg, Caldwell County, Kentucky, which is 3 miles southwest of the type section in Walche's cut on the Illinois Central Railroad. It has commonly been referred to as the "Massive Menard." The member is 30-40 feet thick in the far south, but it thins northward to about 5 feet. Much of the limestone is dense and fine grained to lithographic. Some beds are dolomitic.

**Allard Limestone Member**—The Allard Limestone Member of the Menard Formation (Swann, 1963, p. 38-40) is named for Allard College School, Johnson County, 2.2 miles northeast of the type section, which is in a cut at the south end of the Illinois Central Railroad tunnel (SW NW NE 1, 13S-4E). The Allard Member is dominantly limestone, and it ranges from a little more than 30 feet in the far south to 10-12 feet in much of the northern area of the Menard.

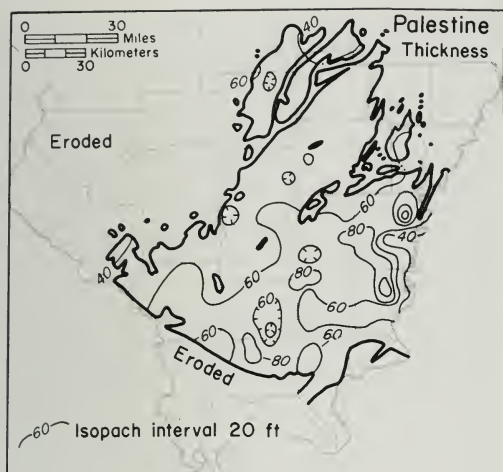


Fig. M-47—Thickness of the Palestine Sandstone.

## Palestine Sandstone

The Palestine Sandstone (S. Weller, 1913, p. 120) is named for Palestine Township, Randolph County, where the type section occurs along tributaries of Tyndall Creek (29, 30, 6S-6W). It is a clastic unit that includes sandstone, shale, and siltstone. The Palestine tends to thicken southward (fig. M-47) but not as markedly as other Chesterian formations. It is commonly 50-60 feet thick, but it ranges from 25 to over 100 feet. It is thickest where massive (channel-phase) sandstone bodies are present. Much of the sandstone is gray, very fine grained, and more or less shaly. The thicker sandstone bodies are lighter colored and coarser grained, and grade to white, medium-grained sandstone. The shale is dark gray and generally silty or sandy. The siltstone is mainly dark gray with a little dark green. Much of the Palestine Sandstone is slightly carbonaceous. An underclay and coal bed mark the top of the Palestine at several localities in western Illinois (Swann, 1963). The Palestine does not have persistent traceable beds, such as characterize the younger Chesterian formations. The sandstone bodies lens rapidly in and out, but in most places the sandstone is in the upper and/or lower parts of the formation, rarely in the middle. Well developed channel sands in the lower part of the formation generally cut into the Menard Limestone. The sandstone bodies in the Palestine have the pattern of a deltaic distributary system (Potter, 1963). Fossil tree trunks of *Lepidodendron* are perhaps more common in the Palestine than in any of the other Chesterian sandstones.

## Clore Formation

The Clore Formation (S. Weller, 1913, p. 120) is named for Clore School, Randolph County, and the type section is in gullies near the school (SE cor. 20, 7S-6W). The formation includes three members, a lower limestone and shale member (Cora), a middle sandstone and shale member (Tygett), and an upper limestone and shale member (Ford Station). Early geologists in places confused the Tygett Sandstone Member with either the Degonia Sandstone or the Palestine Sandstone and confined the Clore

Formation to either the Cora or the Ford Station Member (Swann, 1963). The Clore is 40-60 feet thick near its northern and northwestern limits, and it thickens southward to a little more than 120 feet in parts of Pope and Johnson Counties (fig. M-48). The Clore is thinned by sub-Degonia channels in many more places than are shown in figure M-48. In several areas, sub-Pennsylvanian channels also cut into the Clore. The formation is dominantly shale throughout most of its extent, but the proportion of limestone increases southward. Near the southern outcrop belt the top is stepped up a few feet to include limestone equivalent farther north to the basal portion of the Degonia. At about the same place, the base is stepped down to include limestone equivalent to the uppermost portion of the Palestine. Fossils are generally abundant in the Clore. The fauna is made up mainly of bryozoans and brachiopods. The genera *Archimedes*, *Batostomella*, and *Rhombopora* (fig. M-4) are conspicuous among the bryozoans, and *B. nitidula* is an index fossil. The brachiopods *Spirifer increbescens* and *Composita subquadrata* are especially abundant.

**Cora Limestone Member**—The Cora Limestone Member of the Clore Formation (Swann, 1963, p. 40-41), the lowest member, is named for Cora, Jackson County, and the type section is near by at the mouth of Degonia Creek Hollow (SW SE 16, 8S-5W). The Cora is 15-45 feet thick. It varies from dominantly limestone to dominantly shale. In both facies it is interbedded limestone and shale and locally contains sandstone lenses. A zone in the Cora Member in which the limestone surfaces are covered with delicate branching bryozoans is the *Batostomella nitidula* Peak Zone (S. Weller, 1926).

**Tygett Sandstone Member**—The Tygett Sandstone Member of the Clore Formation (Swann, 1963, p. 40, 42), the middle member, is named for Tygett School, Union County, and the type section is on Bradshaw Creek, 1.5 miles north of the school (NE NW 24, 11S-1W), where it is 26 feet thick. It consists of sandstone and minor amounts of shale. *Sigillaria* trunks and fragments are common in some beds.

**Ford Station Limestone Member**—The Ford Station Limestone Member of the Clore Formation (Swann, 1963, p. 40, 42), the upper member, is named for the Ford Station siding of the Missouri Pacific Railroad, Randolph County, where the type section is in an abandoned quarry (NW SE

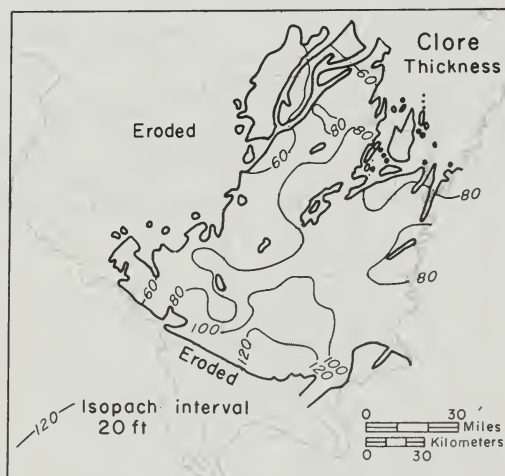


Fig. M-48—Thickness of the Clore Formation.

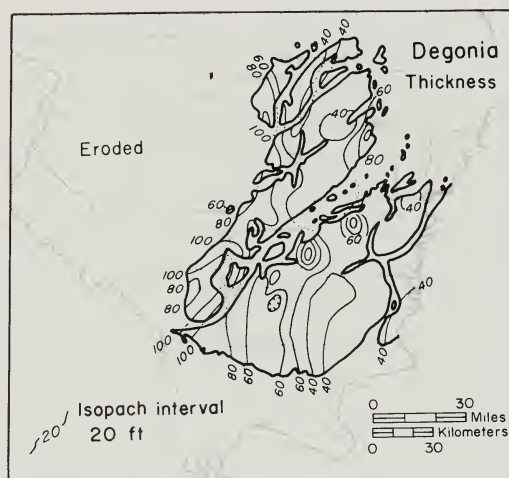


Fig. M-49—Thickness of the Degonia Sandstone.

33, 7S-6W). It is 38 feet thick in the type section but ranges from 20-50 feet thick. It consists of interbedded limestone and shale that include rare lenses of sandstone. Most of the shale in the Ford Station Member is dark gray to dark greenish gray and is generally calcareous and fossiliferous. The limestone is gray, buff, drab, or dark brownish gray, argillaceous, and shaly. Dolomite occurs irregularly.

## Degonia Sandstone

The Degonia Sandstone (S. Weller, 1920, p. 281-290) is named for Degonia Township, Jackson County, where the type section is in the bluffs of the Mississippi River and small tributaries (12-16, 21-25, 8S-5W). It is a clastic unit, dominantly sandstone, that ranges from 150 feet of massive sandstone in western Illinois to as little as 20 feet of shale in the southeast (fig. M-49). Typically, it includes two well developed, lenticular beds of massive sandstone. The upper overlaps the lower and both are absent locally. Most of the shale is gray to dark gray, but an extensive bed of red shale occurs at the top of the formation. Thick elongate and thin sheet sand bodies occur in a dendritic pattern (Potter, 1963). A north-south sandstone body, locally more than 15 miles wide, is joined from the east by southwest-trending bodies that fill channel distributaries. In the thick bodies, the sandstone typically is white and fine grained (Atherton, 1947). In southwestern Illinois thin coal beds occur locally near the top and middle of the formation. The Degonia contains plant remains, with *Lepidodendron* the most common.

## Kinkaid Limestone

The Kinkaid Formation (S. Weller, 1920, p. 281-290; Swann, 1963, p. 42) is named for Kinkaid Creek, Jackson County, where the type section is in exposures along the creek (SE NW NW 6, 8S-4W). It is a limestone-shale unit (fig. M-1C) and is one of the thicker Chesterian formations, commonly 120-160 feet thick. However, pre-Pennsylvanian erosion of valleys trending northeast-southwest has cut the formation, and particularly its upper member, into isolated areas (Bristol and Howard, 1971, 1974). The formation appears to have been highly resis-

tant to erosion, because it caps the Chesterian Series in large areas, and slump blocks of Kinkaid occur on the slopes of steep-walled pre-Pennsylvanian valleys. The formation ranges from about 100 feet thick in the north to a little more than 170 feet near its southern margin (fig. M-50). It is divided into three members—the Negli Creek Limestone Member (below), the Cave Hill Shale Member, and the Goreville Limestone Member. The fauna of the Kinkaid is dominantly brachiopods, bryozoans, and blastoids and resembles that of several older Chesterian limestone formations, although it is less prolific. A species of *Martinia* is very common.

**Negli Creek Limestone Member**—The Negli Creek Limestone Member of the Kinkaid Formation (Logan, 1924, p. 11, 125; Malott, 1925, p. 112-114; Swann, 1963, p. 75), the lowermost member, is named for Negli Creek, Perry County, Indiana, along which the type section is an exposure of 12 feet of limestone (NW 36, 6S-3W). In Illinois it is a massive limestone very similar in thickness and lithology to the Goreville Limestone Member but more extensive. It thickens southward from 16 feet in Effingham County to 37 feet in Franklin County. Most of the limestone is brownish gray, but it has some light gray and brown beds. It is very fine grained but includes coarse grains of fossils. In places the lower part is lithographic. It is cherty, particularly in the upper part, but generally less cherty than the Goreville Member. Algal growths (*Girvanella*) are common in the lower part of the Negli Creek, and large gastropods and small biserial Foraminifera occur near the middle.

**Cave Hill Shale Member**—The Cave Hill Shale Member of the Kinkaid Formation (Swann, 1963, p. 42-43), the middle member, is named for Cave Hill, Saline County, where the type section is on the west slope of the hill (SE SW NW 5, 10S-7E). It is 108 feet thick in the type section, but is over-thickened 25-30 feet by tectonic squeezing. It is a limestone-shale unit about 65 feet thick in the northern area, thickening southward to a little more than 90 feet in the south. The proportion of limestone increases southward, and in the southern area the shale is largely limited to the top and bottom few feet (fig. M-1C). The upper shale, about 15 feet thick, consists of calcareous, dark gray and greenish gray shale at the top and red and green shale below. The red shale makes a fairly extensive marker bed. The middle limestone part contains a variety of carbonate rocks, mainly light brownish gray lithographic limestone, dark shaly limestone,

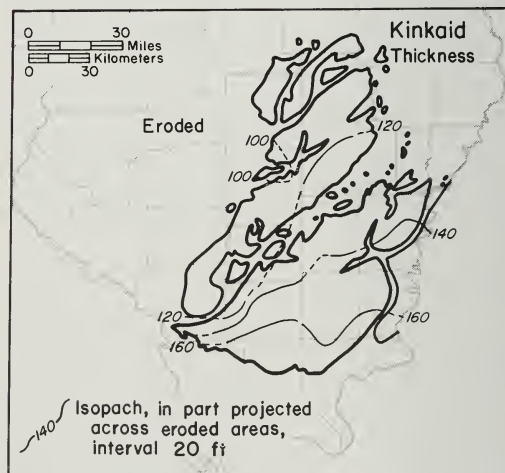


Fig. M-50—Thickness of the Kinkaid Limestone.

and buff dolomite. The interbedded shale is mainly dark gray, but locally some is very dark gray or black. The basal shale, about 15 feet thick, consists of dark gray shale and locally some black shale. The lower third of the Cave Hill commonly includes some silty shale, a little gray to dark gray and green siltstone, and, in places, more or less shaly sandstone.

**Goreville Limestone Member**—The Goreville Limestone Member of the Kinkaid Formation (Swann, 1963, p. 43-44), the uppermost member, is named for Goreville, Johnson County, and the type section is in a quarry at Buncombe, 4 miles south of Goreville (SW SW SE 10, and NW NW NE 15, 12S-2E) (fig. M-1C), where the member is 40.5 feet thick. It is a resistant and relatively uniform, massive limestone about 30 feet thick, but it ranges from about 25 feet in the north to nearly 50 feet in the south. Most of the limestone is brownish gray but some of it is light gray or gray. It is very fine grained but includes coarse fossil grains, mostly crinoidal fragments. It is cherty to slightly cherty nearly everywhere.

### Grove Church Shale

The Grove Church Shale (Swann, 1963, p. 44-45), the uppermost formation in the Chesterian Series in Illinois,

is named for Cedar Grove Church, Johnson County, and the type section is in a roadcut and near-by gullies, 1.25 miles east of Lick Creek (W line NE NW 31, 11S-2E), where the formation is 16 feet thick. The formation has been largely eroded from Illinois by pre-Pennsylvanian erosion, and it occurs only in patches in Johnson, Pope, and Saline Counties, and probably in parts of adjacent counties. The maximum known thickness is 67 feet in the northern half of Johnson County. The Grove Church is a gray, fossiliferous shale and includes interbedded fossiliferous limestone. It was originally part of the Kinkaid Formation, but it was split off because it is dominantly shale. As a result, the Kinkaid is a dominantly limestone formation. It also has a distinctive fauna; some species have affinities to Pennsylvanian fossils, particularly the fusuline *Millerella* and some ostracodes (Cooper, 1947). The conodont fauna differs strikingly from that of the Kinkaid (Rexroad and Burton, 1961). The genus *Streptognathodus* comprises over one-third of the fauna of the Grove Church and there is a marked decrease in *Cavusgnathus*. Transitional forms show that the change is evolutionary, rather than being a migratory influx.

## PENNSYLVANIAN SYSTEM

*M. E. Hopkins and J. A. Simon*

Strata of the Pennsylvanian System constitute the bedrock in about two-thirds of the area of Illinois (36,806 out of 56,400 square miles) and underlie all or parts of 86 of the 102 counties of the state (fig. P-1). The name "Pennsylvanian Series" was introduced by H. S. Williams in a report on Washington County, Arkansas (Simonds, 1891, p. xiii), to designate strata generally called "Coal Measures." Later, the coal fields of Pennsylvania were named as the type area (Williams, 1891, p. 83). The name "Pennsylvanian" has been used in Illinois since the first report of the present Geological Survey (Weller, 1906a), but the terms "Coal Measures" and/or "Upper Carboniferous" were still used in many early reports of the Survey. The Pennsylvanian was classified as a series in Illinois until about 50 years ago and since then has been regarded as a system (fig. P-2).

Throughout most of the area they cover in Illinois, Pennsylvanian strata are concealed by unconsolidated Pleistocene deposits, but in many areas they have been exposed by stream erosion (fig. P-3). The lowermost Pennsylvanian strata are prominently exposed in escarp-

ments that generally face south along the southernmost boundary of the Pennsylvanian, beyond the maximum advance of Pleistocene glaciers. The upper two-thirds of the Pennsylvanian section occurs in relatively flat areas, where the best exposures are generally in artificial cuts made in mining or in highway or railroad construction.

Although the maximum thickness of the Pennsylvanian in Illinois is about 2500 feet, the maximum composite thickness of the individual formations is more than 3300 feet. The formations generally thicken from northern and western Illinois toward the south and southeast. Thickness is also affected by progressive overlap to the north and northwest as lower units pinch out. In much of the Pennsylvanian area of western and northern Illinois, most of the members of the three lowest formations are relatively thin or missing. In places on the La Salle Anticline, these formations are absent and the Colchester (No. 2) Coal at the base of the Carbondale Formation rests directly on the St. Peter Sandstone of Ordovician age. In the extreme northwestern area of Pennsylvanian rocks, however, the

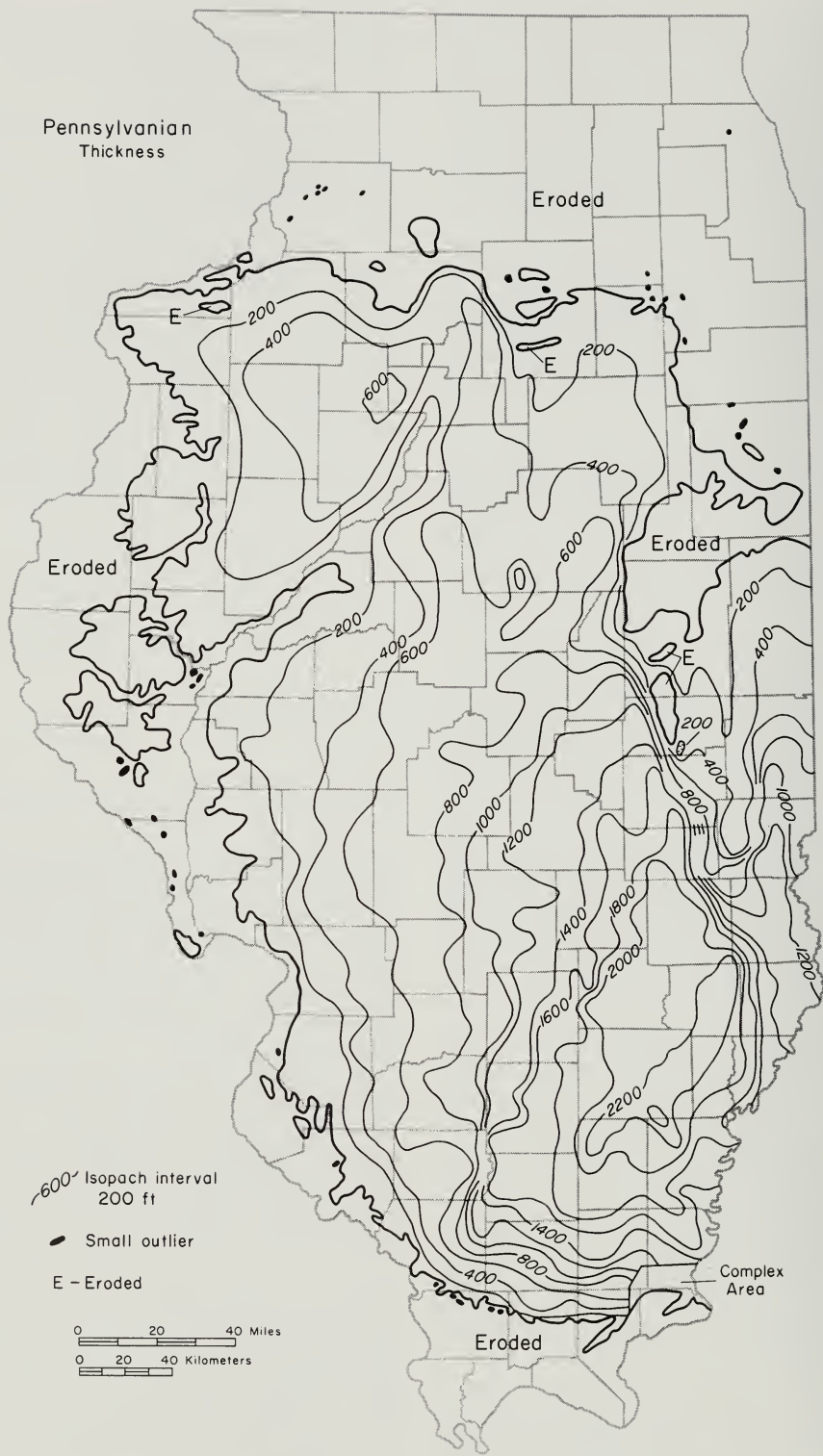
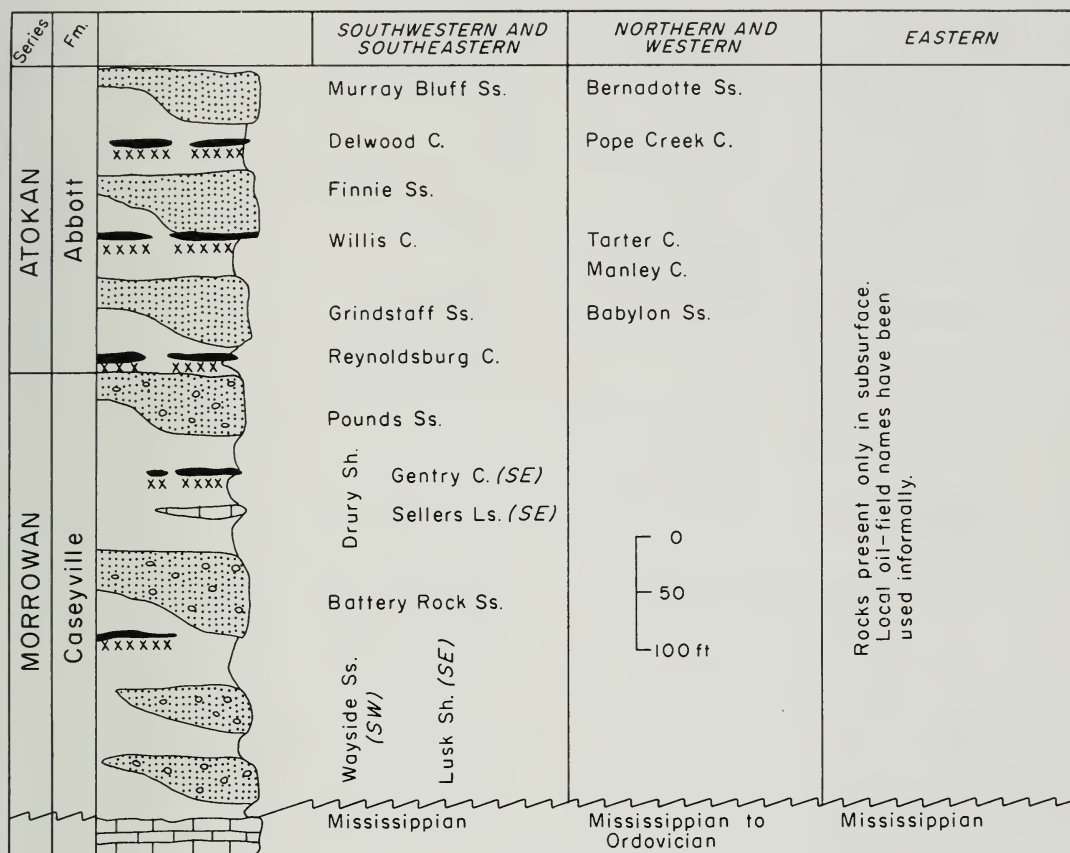


Fig. P-1—Thickness of the Pennsylvanian System.

## McCormick Group



P-2—Classification of the Pennsylvanian System. In the graphic column, blank space indicates gray shale. Named members are listed to the right of the graphic column. Figure is continued on next two pages.

three lowest formations are all well developed, particularly in Rock Island and Mercer Counties.

A major unconformity underlies the Pennsylvanian System (fig. P-4) and separates the Absaroka Sequence, which includes all the Pennsylvanian strata, from the Kaskaskia Sequence below. Pennsylvanian rocks overlie the youngest strata of the Mississippian System in extreme southern Illinois and progressively overlap older strata northward. In the extreme northern part of the coal basin, Pennsylvanian rocks directly overlie rocks of Ordovician and Silurian age.

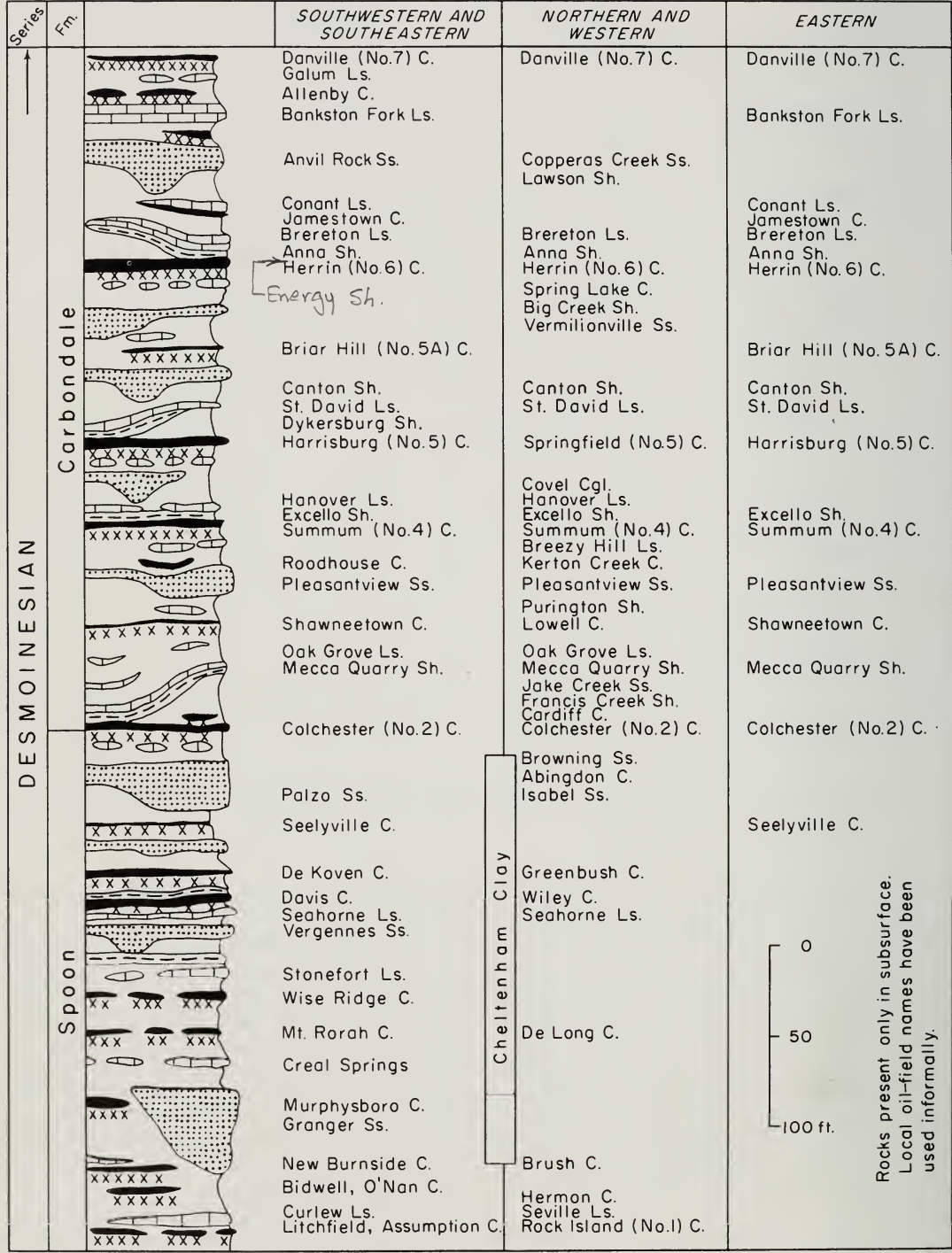
The upper surface of the Pennsylvanian rocks is an eroded post-Pennsylvanian, pre-Pleistocene surface modified in part by further erosion during the Pleistocene (fig. 10). In a relatively small area in Adams, Pike, and Brown Counties in western Illinois, the Penn-

sylvanian is overlain by Gulfian (upper Cretaceous) rocks (Frye et al., 1964).

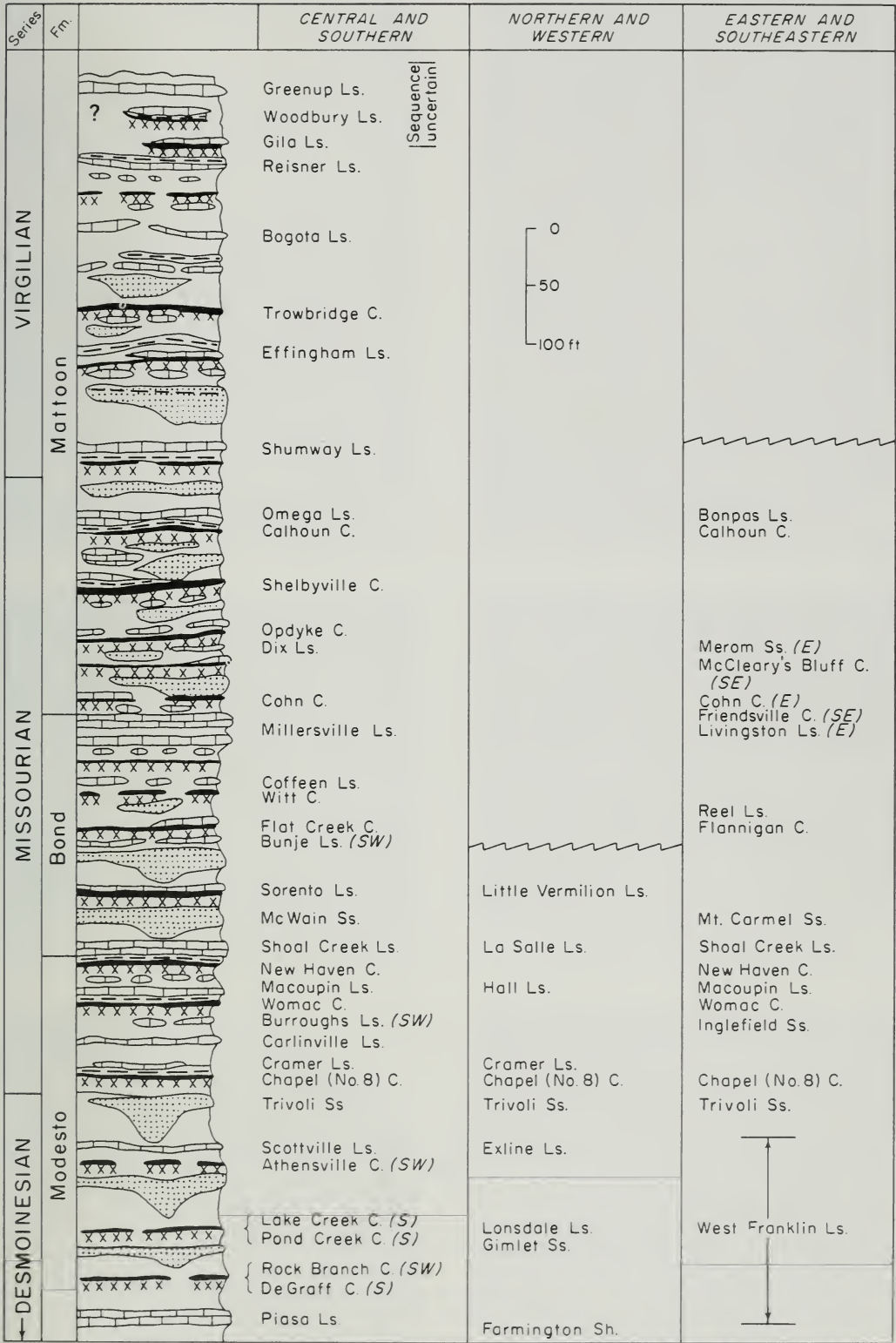
The Pennsylvanian System is characterized by many vertical changes in lithology, commonly abrupt, that produce 500 or more distinguishable units of sandstone, siltstone, shale, limestone, coal, and clay (Kosanke et al., 1960). Many of these units are laterally extensive, and even though others vary lithologically they can be correlated widely because of their positions in relation to continuous marker units, usually limestones, black fissile shales, or coals.

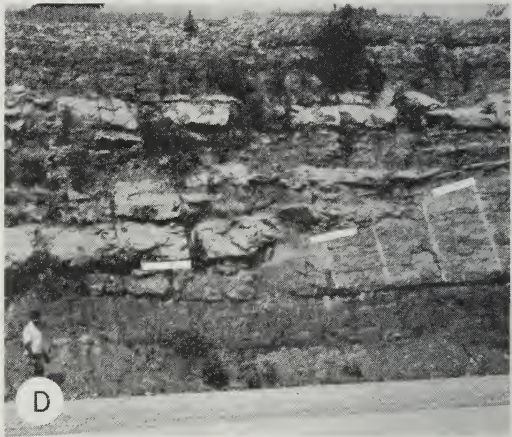
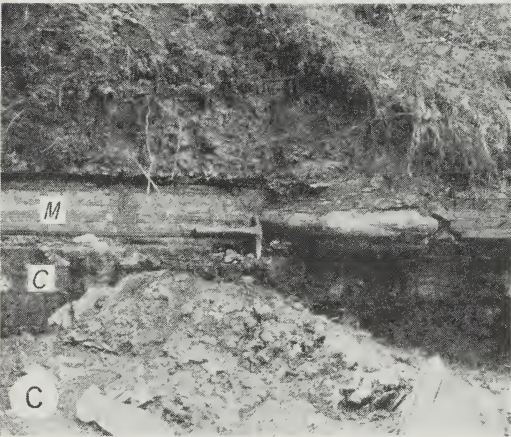
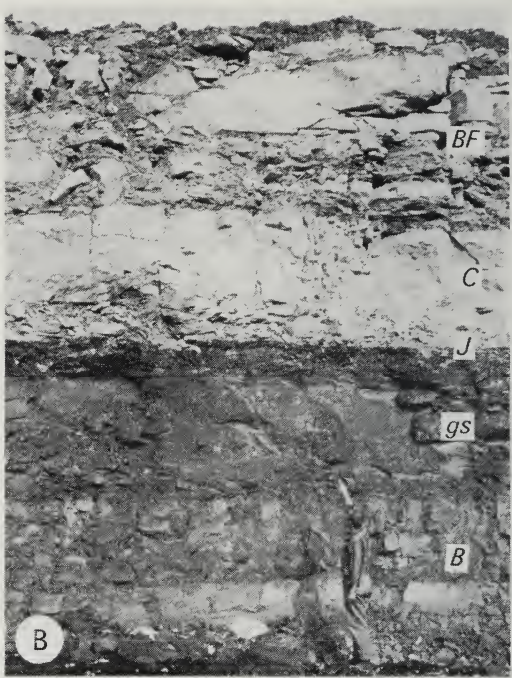
Typically, 90-95 percent of the system consists of clastic rocks. Sandstones commonly constitute 60 percent of the lower part of the section (McCormick Group). Most of the remainder is siltstone and shale, and less than 1 percent is coal and limestone. Sandstones constitute about 25 percent of the middle and

Kewanee Group



McLeansboro Group





upper parts of the system, although the percentage may be somewhat higher in the upper strata. In the upper part of the section, shale (dominantly of various shades of gray with smaller amounts of red, green, and black) and underclay commonly form 65-70 percent of the sequence. In general, 5-10 percent of the upper two-thirds of the sequence is limestone, the largest percentage in the Bond Formation.

Because of the abrupt and distinct vertical variations in lithology and the widespread lateral continuity of many of the Pennsylvanian units, their classification has undergone many changes (fig. P-5). The present Pennsylvanian classification was adopted (Kosanke et al., 1960) to make it conform to the Illinois State Geological Survey policy on stratigraphic nomenclature (Willman et al., 1958) (fig. 16). The multiple classification adopted by the Survey permitted recognition of cycles as a separate and distinct classification, thus removing cyclothems from the rock-stratigraphic classification, where they had been used in place of formations. After several alternatives for formations had been considered, the entire system was subdivided into seven formations, each a bundle of Pennsylvanian strata characterized by certain gross lithologic characteristics and separated from the overlying and underlying strata by the top or bottom of generally widely traceable members. The formations are differentiated by the relative abundance, character, and distribution of four basic lithologies—sandstone, shale, coal, and limestone. Adjacent formations that have closely related lithologic characteristics are combined into a group and three groups are recognized.

The present time-stratigraphic classification of the Pennsylvanian System in Illinois (fig. P-2) is based on that developed in the Midcontinent Region and was first published by the Illinois State Geological Survey on the Geologic Map of Illinois (Willman et al., 1967). Correlations with Midcontinent strata

are based on both biostratigraphy and rock stratigraphy, and many biozones and rock units of the Midcontinent Region can be identified in the Illinois Basin. The sediments were continuous before the two regions were separated by post-Pennsylvanian erosion. A time-stratigraphic classification of the Pennsylvanian System in Illinois based on ostracodes (Cooper, 1946) used Midcontinent terms, but the correlations were not definitive and the classification was not followed.

The most common invertebrate macrofossils are brachiopods, crinoids, gastropods, and pelecypods, but corals, cephalopods, trilobites, foraminifers, bryozoans, and worms occur in some beds (fig. P-6) (Wanless, 1958). Biostratigraphic zones in the Pennsylvanian in Illinois are based on fusulinids (Dunbar and Henbest, 1942; Thompson et al., 1959; Thompson and Shaver, 1964), ostracodes (Cooper, 1946), and spores (Kosanke, 1950; Peppers, 1964, 1970; Winslow, 1959). Moore et al. (1944) discussed ranges of all fossil types in the Pennsylvanian of the United States. Floral zones for the nation as a whole were described by Read and Mamay (1964).

Coal-bearing Pennsylvanian strata have been fairly precisely correlated from spores and pollen in the coals. Palynological studies of other lithologic units, however, have not been extensive. Major time-stratigraphic intervals are delineated by their most abundant spore taxa and by the occurrence of certain genera and species that have relatively short stratigraphic ranges. Some of these fossils are limited to two or three coals, whereas others extend through one or more series. A coal can generally be precisely correlated with a named coal member, or at least placed within an interval containing two or three named coal members.

The Pennsylvanian of Illinois includes strata belonging to the recognized series of the Midcontinent, from oldest to youngest: Morrowan, Atokan, Desmoinesian, Missourian,

Fig. P-3—Exposures of Pennsylvanian rocks.

- A—Battery Rock Sandstone Member of the Caseyville Formation capping an escarpment 8 miles north of Cave in Rock, Hardin County.
- B—Strata overlying the Herrin (No. 6) Coal Member of the Carbondale Formation (at the man's feet), including the Bankston Fork Limestone Member (BF), Conant Limestone Member (C), Jamestown Coal Member (J, 1 inch thick), gray calcareous shale (gs), Brereton Limestone Member (B); in a strip mine southwest of Bellevue, St. Clair County.
- C—Mecca Quarry Shale Member (M) of the Carbondale Formation in which a large limestone concretion is present (at the hammer), overlying the Colchester (No. 2) Coal Member (C) just south of Viola, Mercer County.
- D—The sub-Absaroka unconformity showing Pennsylvanian strata (Caseyville Formation) truncating Mississippian strata (Kinkaid Limestone) in a roadcut of U.S. Highway 51, north of Anna, Union County.
- E—Asymmetrical current ripple marks and weak current laminations (parallel to hammer) in thin-bedded sandstone in the Caseyville Formation, near Pomona, Jackson County.
- F—Quartz-pebble conglomerate in the Caseyville Formation near Shiloh Hill, Randolph County.

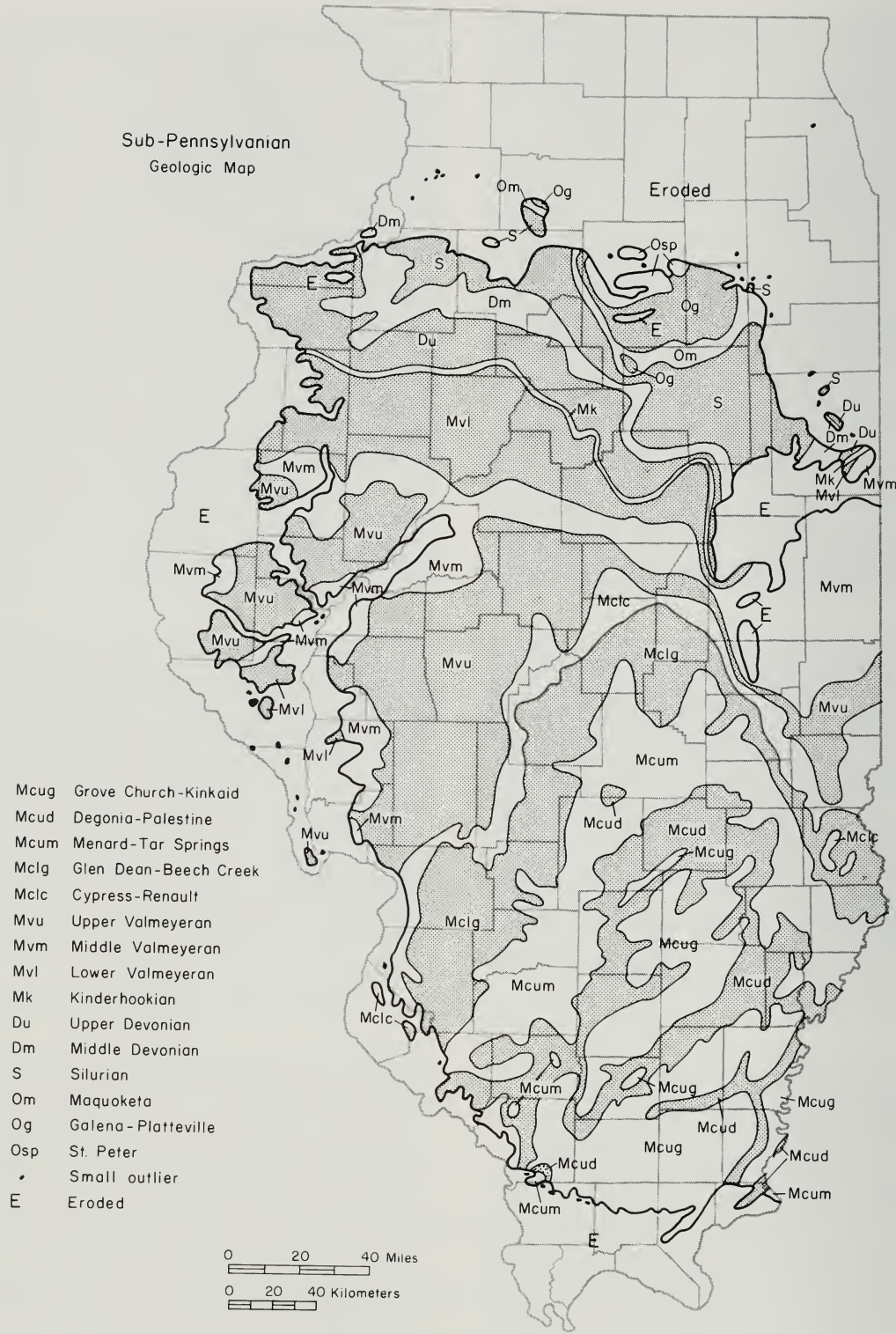


Fig. P-4—Geologic map of the sub-Pennsylvanian (sub-Absaroka) surface (after Willman et al., 1967).



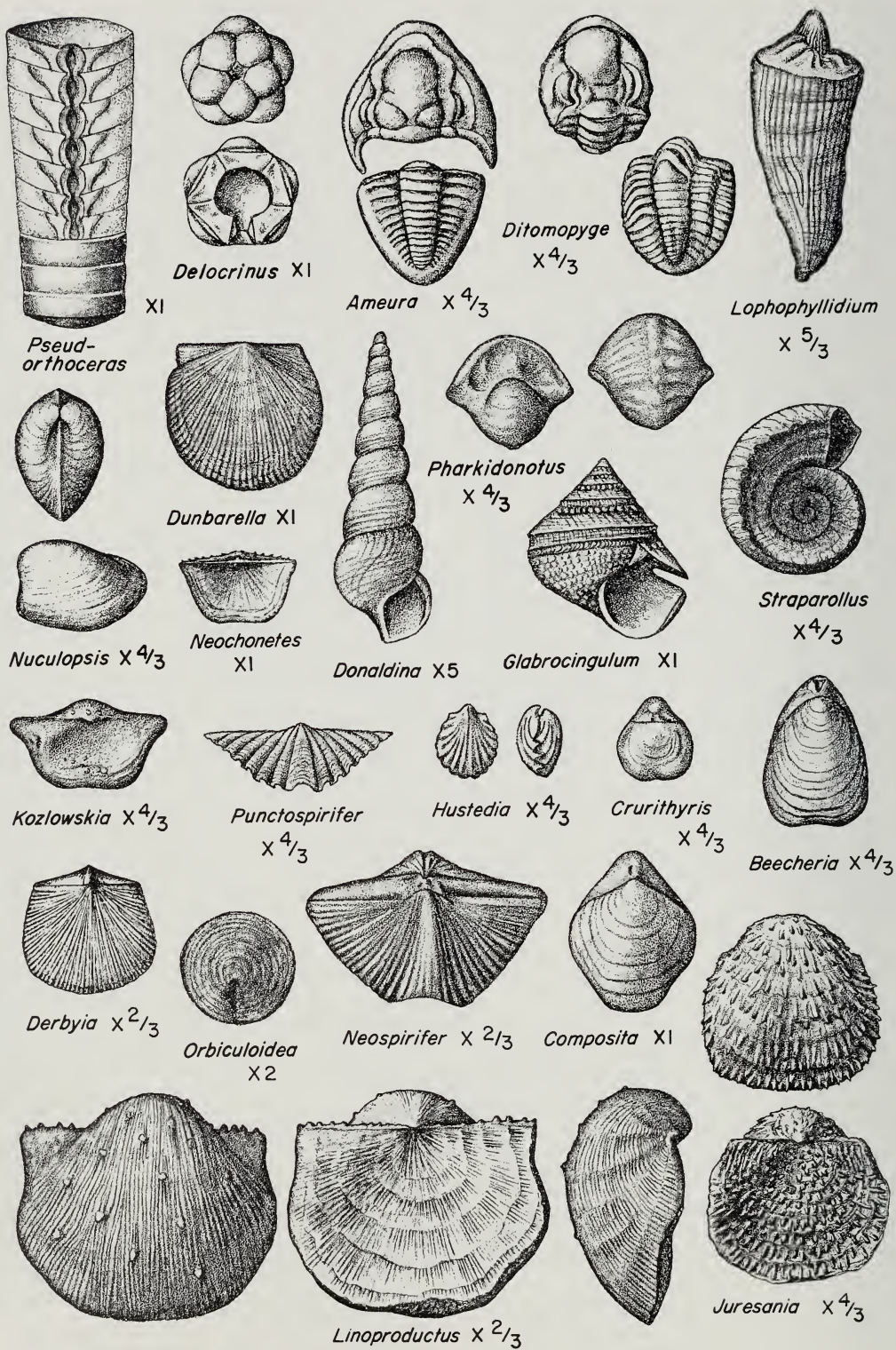


Fig. P-6—Typical Pennsylvanian fossils.

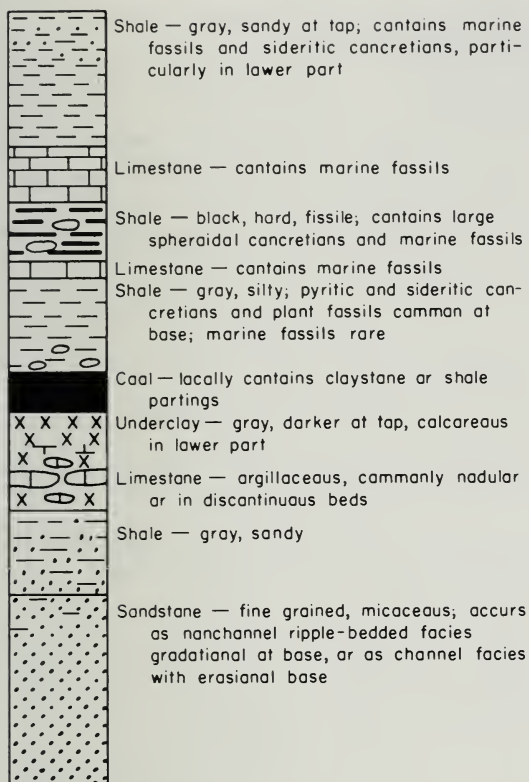


Fig. P-7—Arrangement of lithologic units in a cyclothem (after Willman and Payne, 1942).

and Virgilian (fig. P-2). Older strata of problematical age, sometimes referred to as the Springeran Series (Pennsylvanian and/or Mississippian), have not been recognized in Illinois. However, certain sink-hole or cave deposits lying on or in older carbonates in western and northeastern Illinois contain very early Pennsylvanian strata that have not been correlated with strata in other areas, although they are at present considered Morrowan. Because of the overlapping relations on the unconformity at the base of the Pennsylvanian, the basal Pennsylvanian strata vary in age, generally from Morrowan in southern Illinois to Atokan and Desmoinesian in western, northern, and eastern Illinois. The youngest Pennsylvanian strata in Illinois, found only at the top of the deepest part of the Fairfield Basin, belong in the lower part of the Virgilian Series. The spores of several coals preserved in down-faulted blocks in western Kentucky and adjacent southeastern Illinois suggest that most of the Virgilian may be represented in this part of the basin. Within the Pennsylvanian System in Illinois, no major, widespread

unconformities with either large-scale overlaps or structural discordances are evident. Numerous erosional episodes, however, occurred during the development of fluvial and deltaic sandstones.

The many individual units of the Pennsylvanian generally occur in an orderly sequence, and the sequences are repeated many times throughout most of the succession. Although the idealized sequence shown in figure P-7 is rarely complete, the units that are present have the same relative position in the sequence. These sequences were early recognized as cycles of sedimentation (Udden, 1912; Weller, 1930, 1931) and were subsequently termed "cyclothems" (Wanless and Weller, 1932).

Cyclothems have been used extensively in geologic reports in the past 40 years (Wanless, 1929 [called suites], 1931a [called cyclical formations], 1957; Willman and Payne, 1942), but they are not entirely adequate for rock-stratigraphic classification. They are much smaller units than the formations and are most useful in detailed differentiation and field mapping of the Pennsylvanian sediments. The named cyclothems are listed in table 3.

Pennsylvanian sediments of the Illinois Basin were deposited in a gently subsiding trough that was open toward the south until post-Pennsylvanian time, when it was closed by uplift of the Pascola Arch south of Illinois. The greatest subsidence took place in the southeastern part of the state where the system is thickest.

Because of subsidence during and after the Pennsylvanian, the base of the Pennsylvanian is as much as 2500 feet lower in the deeper part of the basin than at the surface around the margin, and the Herrin (No. 6) Coal is as much as 1400 feet lower (fig. P-8). The major structural features within the Illinois Basin that influence the present distribution of Pennsylvanian strata are the La Salle Anticlinal Belt, the Fairfield Basin, the Du Quoin Monocline, and the Eagle Valley Syncline, which is in southeastern Illinois south of the Shawneetown Fault (fig. 12). Faulting is most prominent in southeastern Illinois, where the faults of the fluorspar district have caused Pennsylvanian strata to be preserved in grabens south of the principal margins of the Pennsylvanian. The distribution of Pennsylvanian formations is also influenced by the Shawneetown Fault, the Cottage Grove Fault System, and the Wabash Valley Fault System. Pennsylvanian outliers in southern Calhoun County are related to the Cap au Grès Faulted

**TABLE 3—ALPHABETIC LIST OF NAMED CYCLOTHEMS IN ILLINOIS, SHOWING FORMATION, DISTRIBUTION, AND PRINCIPAL REFERENCES**  
(after Kosanke et al., 1960)

Named cyclothem	Formation	Area of state	References
Abingdon	Spoon	Western	Weller et al., 1942b, p. 1586
Babylon	Abbott	Western	Wanless, 1931a, p. 189-190, 192-193; 1957, geol. sec. 41, p. 189
Bankston	Carbondale	Southwestern and southeastern	Weller, <i>in</i> Dunbar and Henbest, 1942, p. 16-18; Wanless, 1956, p. 11
Battery Rock	Caseyville	Southwestern and southeastern	Weller, 1940, p. 37; Wanless, 1938
Bogota	Mattoon	Central	Newton and Weller, 1937, p. 9, 19-24; Wanless, 1956, p. 12
Brereton	Carbondale	All	Wanless, 1931a, p. 180, 182-183, 190, 192
Briar Hill	Carbondale	Southwestern and southeastern	Kosanke et al., 1960; previous name, Crab Orchard Cyclothem, Wanless, 1938; Weller et al., 1942a, p. 16
Brush	Spoon	Western	Kosanke et al., 1960; previous name, Middle De Long Cyclothem, Wanless, 1931a, p. 188, 192; 1956, p. 9
Bunje	Bond	Southwestern	Kosanke et al., 1960; Wanless, 1955, p. 1764 (from Simon ms., 1946)
Carlinville	Macoupin	Southwestern	Ball, 1952, p. 34-37
Cohn	Mattoon	Eastern	Newton and Weller, 1937, p. 9, 18-19
Colbert	Spoon	Southeastern	Wanless, 1956, p. 5, 9
Cutler	Carbondale-Modesto	Southwestern, southeastern, and eastern	Kosanke et al., 1960; Siever, <i>in</i> Wanless, 1956
De Koven	Spoon	Southeastern	Weller, <i>in</i> Dunbar and Henbest, 1942, p. 16; Wanless, 1956, p. 10
De Long	Spoon	Western	Kosanke et al., 1960; previous name, Upper De Long Cyclothem, Wanless, 1931a, p. 188, 192; 1956, p. 9
Delwood	Abbott	Southeastern	Weller, 1940, p. 39; Wanless, 1956, p. 9
Fithian	Bond	Eastern	White et al., 1958, p. 1-3
Flannigan	Bond	Southeastern	Newton and Weller, 1937, p. 9-10
Flat Creek	Bond	Southwestern	Kosanke et al., 1960; Wanless, 1955, p. 1764 (from Simon ms., 1946)
Gila	Mattoon	Central	Newton and Weller, 1937, p. 9, 27-28
Gimlet	Modesto	Western, northern, southeastern, and eastern	Wanless, 1931a, p. 182, 192
Greenbush	Spoon	Western	Wanless, 1931a, p. 188, 192; 1956, p. 10
Greenup	Mattoon	Central	Newton and Weller, 1937, p. 9, 26-27
Grindstaff	Abbott	Southwestern and southeastern	Butts, 1925, p. 44; Weller, 1940, p. 39
Hall	Modesto	Northern	Weller, <i>in</i> Cooper, 1946, p. 12 (from Willman ms., 1931)
Hermon	Spoon	Western	Kosanke et al., 1960; previous name, Lower De Long Cyclothem, Wanless, 1931a, p. 188, 192; 1957, p. 73
Hicks	Modesto	Northern	Weller, <i>in</i> Cooper, 1946, p. 12 (from Willman ms., 1931)
Jamestown	Carbondale	Southeastern and eastern	Bell et al., 1931, p. 3; Wanless and Weller, 1932, p. 1007; Wanless, 1956, p. 10
La Salle	Modesto-Bond	Northern	Weller and Bell, 1936, p. 26 (from Willman ms., 1931)
Little Vermilion	Bond	Northern	Weller, <i>in</i> Cooper, 1946, p. 14; Cooper, 1946, p. 16 (from Willman ms., 1931)
Liverpool	Spoon-Carbondale	Western	Wanless, 1931a, p. 188, 192; 1956, p. 10; 1957, p. 85 and geol. secs. 24, 25, p. 198
Lowell	Carbondale	Northern	Willman and Payne, 1942, p. 87, 102-103, and geol. sec. 33, p. 300

(Continued on next page)

TABLE 3—Concluded

Named cyclothem	Formation	Area of state	References
Lusk	Caseyville	Southeastern	Weller, 1940, p. 36-37
Macedonia	Abbott-Spoon	Southeastern	Weller, 1940, p. 39, 40; Wanless, 1956, p. 9
Macoupin	Modesto	Southwestern	Wanless, 1931b, p. 804, 811-812; Ball, 1952, geol. sec. 19, p. 85-86
Newton	Mattoon	Central	Newton and Weller, 1937, p. 9, 24-25
Omega	Mattoon	Central	Weller and Bell, 1936, p. 29-32; Wanless, 1956, p. 12
Pope Creek	Abbott	Western	Wanless, 1931a, p. 189-190, 192; 1957, p. 67-70
Pounds	Caseyville-Abbott	Southwestern and southeastern	Wanless, 1929, geol. sec. 4, p. 52, "Suite I"; Weller, 1940, p. 38-39
St. David	Carbondale	All	Wanless, 1931a, p. 182, 192; 1957, p. 102 and geol. sec. 21, p. 197
Seahorne	Spoon	Western and southwestern	Wanless, 1931a, p. 188, 192; 1957, p. 76 and geol. sec. 30, p. 200
Seville	Abbott-Spoon	Western	Wanless, 1931a, p. 189, 192; 1957, p. 70 and geol. sec. 33, p. 201
Shoal Creek	Modesto-Bond	Southwestern, southeastern, and eastern	Wanless, 1931b, p. 804, 812
Shumway	Mattoon	Central	Weller, <i>in</i> Dunbar and Henbest, 1942, p. 28; Wanless, 1956, p. 12
Sorento	Bond	Southwestern	Kosanke et al., 1960; Wanless, 1955, p. 1764 (from Simon ms., 1946)
Sparland	Carbondale-Modesto	Western and northern	Wanless, 1931a, p. 182, 192
Stonefort	Spoon	Southeastern	Kosanke et al., 1960; Weller, 1940, p. 39; Wanless, 1956, p. 9 (location in error)
Summum	Carbondale	All	Wanless, 1931a, p. 182, 192; 1957, p. 94 and geol. sec. 39, p. 204
Tarter	Abbott	Western	Wanless, 1956, p. 9; 1957, p. 66 and geol. sec. 34, p. 202
Tonica	Spoon-Carbondale	Northern	Kosanke et al., 1960; previously called Liverpool Cyclothem in northern Illinois (Willman and Payne, 1942, p. 95)
Trivoli	Modesto	All	Wanless, 1931a, p. 182, 192; 1956, p. 11; 1957, p. 121 and geol. sec. 8, p. 193
Wiley	Spoon	Western	Wanless, 1931a, p. 188, 192; 1956, p. 9; 1957, p. 79 and geol. sec. 42, p. 206
Witt	Bond	Southwestern	Kosanke et al., 1960 (from Gluskoter ms., 1958)
Woodbury	Mattoon	Central	Newton and Weller, 1937, p. 9, 28-30

Flexure. Numerous other flexures in the Pennsylvanian rocks in the basin are commonly related to structures that have greater relief in pre-Pennsylvanian strata. Domal structures in Pennsylvanian strata overlie many Silurian reefs.

The Pennsylvanian section is generally thinner in the area of the Sparta Shelf west of the Du Quoin Monocline in southwestern Illinois and in the shelf area north and west of the Illinois River. In both areas much of the section is present, but the lowermost or oldest strata were not deposited there and the youngest strata probably have been eroded from the area.

During Pennsylvanian time clastic sedi-

ments were generally carried into the seas occupying the Illinois Basin area by rivers flowing from the north, northeast, and east, and to a lesser extent from the northwest. When the seas withdrew, most of the major rivers flowed southwestward across Illinois. Much of the sedimentation occurred in large deltas on the gently subsiding basin (Wanless et al., 1963). The marine, brackish water, and delta-plain sediments have complex relations, and there is little agreement on interpretations of the environment of deposition of some strata.

Sandstones occur in two broad general types—channel facies and sheet facies (Andresen, 1961; Hopkins, 1958; Potter, 1962b,

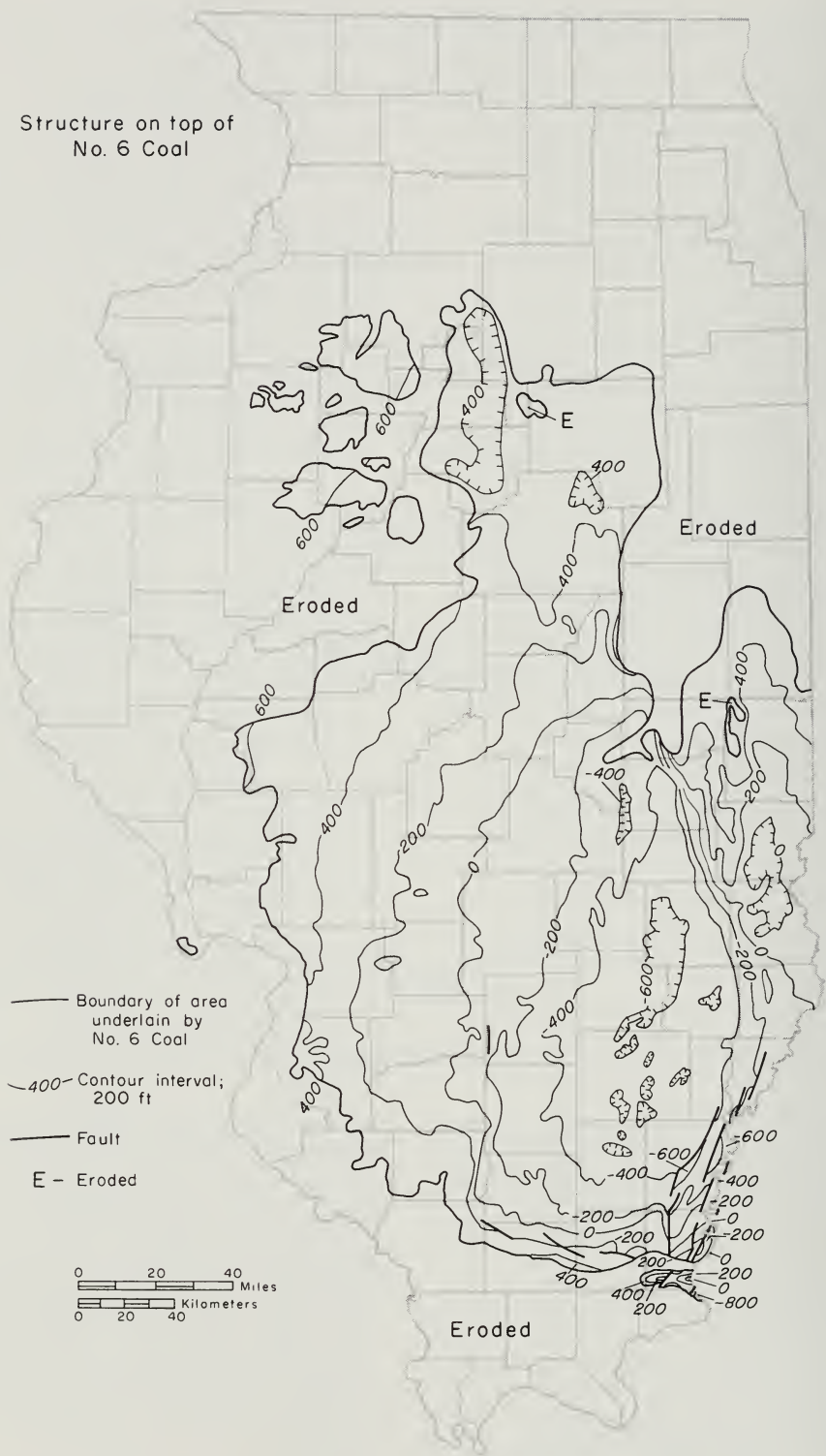


Fig. P-8—Structure of the top of the Herrin (No. 6) Coal Member (based on map by K. E. Clegg).

1963; Siever, 1957). Sandstones in channels are generally less than 100 feet thick, but where channels cross and two or more sandstones are in vertical juxtaposition, thicknesses of more than 100 feet are found. Some channel sandstones abruptly truncate lower strata in long, winding courses, suggesting that the sand filled valleys that had been subaerially eroded. The lower surface of the channel sandstone generally truncates sharply the strata below, but the upper surface commonly grades into the overlying rocks, which are generally siltstone. Most sandstones appear to be nonmarine, although some are clearly marine. The sheet sandstones are thinner than the channel sandstones and occur in widely traceable layers that commonly are conformable with strata above and below. Siltstones are common but generally are not as thick as the channel sandstones or some shales.

The shales that overlie limestones in the normal cyclical sequence are generally marine. The black fissile shales, which commonly occupy a position between a marine limestone and the top of the underlying coal, were marine muds deposited in restricted deoxygenated bottom waters. The gray shales that occur in several areas as large wedges or lenses between the black fissile shale and the coal were deposited in transitional environments, which probably ranged from prodelta to delta front to valley flat. The underclays below most coals or coal positions probably were deposited in relatively fresh water. Claystones other than underclays, commonly associated with the lighter colored marine limestones, generally are also marine.

Nearly 50 coals have been named in the Pennsylvanian of Illinois, but other coals, which are known to be present although as yet unnamed, bring the total to at least 75. Many of the coals are very widespread. The coals accumulated on broad delta plains in fresh-water environments, probably only slightly above sea level (Wanless et al., 1969). Some interstratified partings of mineral matter, mostly clay, also are extensive. The most notable example is the so-called "blue-band" in the lower part of the Herrin (No. 6) Coal Member, a 1- to 3-inch clay parting that has been traced almost continuously throughout thousands of square miles.

Most limestones in the cyclical sequence above the coals were deposited in a marine environment and contain a large variety of fossils. Some limestones are relatively pure, particularly in younger Pennsylvanian strata, but most are characteristically argillaceous. Most of the nodular limestones that occur in a

clay matrix in or below underclays are generally nonfossiliferous but some of them contain algal remains, ostracodes, and the worm *Spirorbis*. They are generally regarded as fresh-water deposits, but some grade into marine limestone in a few areas.

Conglomerates composed of granules and pebbles of locally derived rocks are present at places in the channel sandstone deposits. Lenses and beds of conglomerate consisting of quartz pebbles derived from outside the Illinois Basin occur in sandstones in the Caseyville Formation. The Covell Conglomerate Member is a thin, unique, widespread limestone conglomerate that occurs a short distance below the Springfield (No. 5) Coal Member in northern Illinois. Claystone conglomerates or breccias altered to almost pure kaolinite commonly occupy the stratigraphic position of coals in channel fill in a few local areas (Smith and O'Brien, 1965).

## MORROWAN SERIES

The Morrowan Series of the Pennsylvanian System (Adams, 1904, p. 28) is named for Morrow, Washington County, Arkansas, which lies a short distance from the type exposure on Hale Mountain. The series consists of marine and nonmarine rocks. The Caseyville Formation of the McCormick Group (fig. P-2) constitutes the entire Morrowan Series in Illinois (Willman et al., 1967). The top of the series may not correlate precisely with the top in the Midcontinent section.

Marine fossils are rare in the Caseyville, but the Sellers Limestone Member in southeastern Illinois contains a Morrowan fauna. The type region of the Morrowan in many places contains *Millerella*, a nonfusiform fusulinid that is also found in the Chesterian Series and in younger Pennsylvanian sediments and is the most advanced fusulinid found in Morrowan rocks. However, no fusulinids have been found in the Illinois Morrowan. The upper limit of the Morrowan in fusulinid-bearing rocks is placed at the base of the first strata containing *Profusulinella*.

The compression plant fossils of the Morrowan Series are in Zone 6 (*Neuropteris tenesseeana* and *Mariopteris pygmaea*) of Read and Mamay (1964). The roof shale of the Baldwin coal, which occurs in the Morrowan type section, contains a plant-impression flora similar to that above the Gentry Coal Member in southeastern Illinois. The relative ages of strata within the Morrowan Series in Illinois can best be determined from the spores,

which are abundant in Caseyville sediments, especially the coals. The Morrowan Series in Illinois is dominated by the genus *Lycospora*, which in some coals makes up as much as 80 percent of the spore population. Spores of herbaceous lycopods—*Densosporites*, *Cristatisporites*, and *Radiizonates*—are also abundant. *D. sinosus*, *R. striatus*, and *R. irregularis* are useful guide fossils for the lower part of the Morrowan, whereas *C. indignibundus* is typically found in the upper part. *Schulzospora* ranges up to the top of the Morrowan. *Triquitrites*, *Laevigatosporites*, and *Endosporites* are found in the lower part of the Morrowan but are very rare.

## ABSAROKA SEQUENCE

The major unconformity at the base of the Pennsylvanian System marks the base of the Absaroka Sequence (Sloss et al., 1949, p. 121) (fig. 14), which is named for the Absaroka Mountains in northwestern Wyoming and southern Montana. In Illinois the sequence includes only the strata of the Pennsylvanian System, and its top is the major unconformity at the base of the Cretaceous System (Swann and Willman, 1961). Clastic sediments—shale, sandstone, and siltstone—dominate the sequence. Minor unconformities consisting of deeply entrenched valley systems occur within the Absaroka, but many of the erosional channels in the sequence were produced by entrenchment of river distributaries in deltaic sediments. Except for minor sedimentational dips on local structures, the strata in the sequence are essentially parallel. In the Appalachian Basin and the Midcontinent areas, this sequence continues upward into the Permian System, but no Permian rocks have been found in Illinois. The basal unconformity separating the Absaroka from the underlying Kaskaskia Sequence (fig. P-3D) has been characterized (Siever, 1951; Wanless, 1955; Bristol and Howard, 1971) as an erosion surface formed by streams draining to the south and southeast in western Illinois and to the southwest in central and southern Illinois. The surface has local relief of as much as 450 feet and relatively steep-sided valleys. It truncates all the older Paleozoic systems except the Cambrian (fig. P-4).

## McCormick Group

The McCormick Group (Kosanke et al., 1960, p. 28) is named for McCormick in northwestern Pope County, where the various units of this group are prominently exposed.

In Illinois the McCormick Group comprises strata of the Caseyville and Abbott Formations, from the base of the Pennsylvanian to the top of the Bernadotte Sandstone Member (fig. P-2). The McCormick Group comprises strata formerly included in the Tradewater and Caseyville Groups (Wanless, 1939; Weller, 1940). The McCormick Group in Illinois thickens from about 200 feet at the northwestern extent of the Pennsylvanian to at least 600 feet in southern Illinois, but it is absent in substantial areas in both western and northern Illinois. Lithologically, this group is almost entirely detrital. It is made up of 50-60 percent massive, predominantly cross-bedded, relatively pure quartz sandstone and 40 percent or more sandy shale and siltstone. The sandstones are seldom more than 100 feet thick. A few thin, nonpersistent coals and rare fossiliferous limestones occur locally. Several of the fine-grained sandstones and a few shales are calcareous in places and contain marine invertebrate fossils, but the bulk of the units of the McCormick Group are barren of animal fossils.

## Caseyville Formation

The Caseyville Formation of the McCormick Group (Owen, 1856, p. 48) is named for Caseyville, on the Ohio River in southwestern Union County, Kentucky, near the type locality, "measured from outcrops on the Illinois shore of the Ohio River between the mouth of the Saline River and Gentry's Landing below Battery Rock," in Hardin County (Lee, 1916, p. 15-16). A well exposed reference section has been described along the Illinois Central Gulf Railroad in Pope County (NW SW SE 31, 11S-5E to NE SE NE 18, 12S-5E) (Kosanke et al., 1960, p. 28, 61-62). The Caseyville includes strata from the base of the Pennsylvanian to the top of the Pounds Sandstone Member. The top of the Pounds is generally difficult to recognize in the subsurface north of its outcrop.

The Caseyville Formation is widespread in southern Illinois, and rocks of similar age have been reported in northwestern Illinois in parts of Mercer and Rock Island Counties (fig. P-9). In southern Illinois the Caseyville Formation is as much as 500 feet thick, but 350 feet is a common maximum elsewhere. The Caseyville varies abruptly in thickness because the unconformable surface on which it was deposited has a relief of a few hundred feet—from the bottom of large valleys to the flat upland divides (Siever, 1951; Wanless, 1955; Bristol and Howard, 1971). To the north the Caseyville thins to zero and is overlapped by the Abbott Formation (fig. P-9). In Mercer and Rock Island Counties, the formation varies in thickness; it locally exceeds 100 feet.

The Caseyville Formation is primarily sandstone (fig. P-3A), siltstone, and shale. The sandstones are composed of quartz and very little clay or mica. Most contain quartz granules and pebbles, commonly less than half an inch (12 mm) in diameter, which occur either scattered throughout the sandstone or concentrated in beds of con-

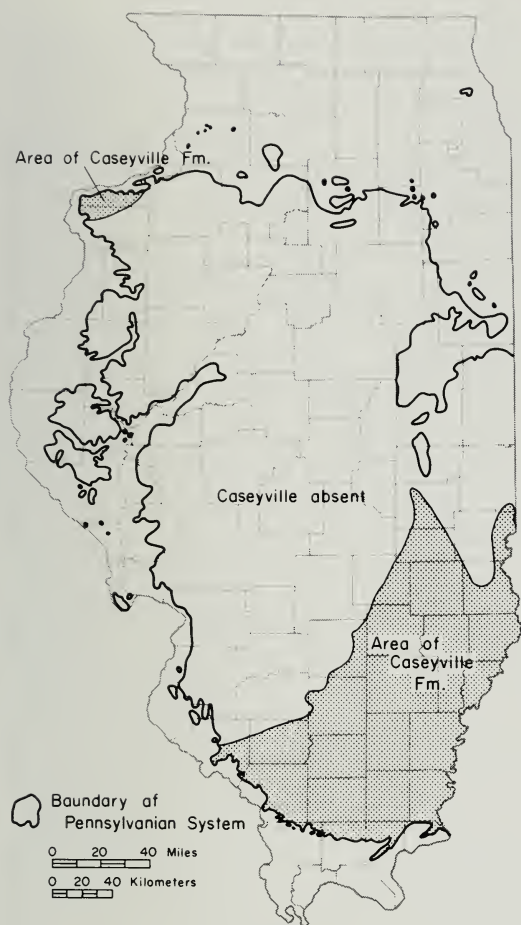


Fig. P-9—Extent of the Caseyville Formation (after Wanless, 1955).

glomerate (fig. P-3F). The coarser sandstones reach about 100 feet thick and show relatively uniform cross-bedding with dip directions to the west, south, or southwest (Potter and Olsen, 1954; Potter, 1962b, 1963) parallel to the direction of elongation of the sandstone bodies. In the finer grained sandstone units, which are usually less than 25 feet thick, the most prevalent sedimentary structure is ripple bedding (fig. P-3E). Shale or siltstone interbeds are common. Considerable oil has been produced for many years in the La Salle Anticlinal Belt in eastern Illinois from sandstones in the Caseyville.

The shales and siltstones are not as widely exposed. The thicker shale units in the Lusk and Drury Members are sandy and contain several beds of sandstone, some relatively coarse grained. A few shales associated with coals are dark, relatively fine and uniform, and their clay mineral content is high. Most of the Caseyville in northwestern Illinois is composed of medium gray to dark gray brittle shales interbedded with silty shales and a few clean quartz sandstones.

Several coal seams, most of them somewhat lenticular, are found in the Caseyville Formation, although only

one—the Gentry Coal Member in southeastern Illinois—is named. In Rock Island and Mercer Counties, as many as seven impure coals up to 2 feet thick occur in the Caseyville (Searight and Smith, 1969).

Limestones are rare in the Caseyville Formation, the only one named being the Sellers Limestone Member, which is exposed in only one small area along the Ohio River Valley. Marine invertebrate fossils are found in this limestone, as well as in a few calcareous sandstone units, some of which contain reworked Mississippian fossils. The formation is otherwise barren of animal fossils.

The upper limit of the Caseyville, which is the top of the Pounds Sandstone Member, is commonly difficult to recognize in the subsurface north of its outcrop belt. Consequently, no separate map of the Caseyville thickness was prepared, but figure P-10 shows the combined thickness of the Caseyville, Abbott, and Spoon Formations. Included are strata from the base of the Pennsylvanian up to the base of the Colchester (No. 2) Coal, a widely recognizable key member that has been traced throughout the state. The Caseyville of Illinois correlates with all but the upper few feet of the Caseyville Formation of western Kentucky and with the lower part of the Mansfield Formation of Indiana.

**Lusk Shale Member**—The Lusk Shale Member of the Caseyville Formation (Weller, 1940, p. 36), the basal unit of the Pennsylvanian System in southeastern Illinois, is named for Lusk Creek in Pope County. The type section consists of exposures along the creek north of Waltersburg (12, 13S-6E). The thickness of the Lusk varies from zero to over 200 feet. The member is composed of various amounts of silty shale, siltstone, and sandstone. Quartz pebbles are common to abundant in some sandstone units as much as 25 feet or more thick, and these units are similar to the Battery Rock and Pounds Sandstone Members. Other sandstone units as much as 50 feet thick are fine grained. The Lusk contains a few thin, unnamed, nonpersistent coal seams and a few zones with marine fossils, most of them fragmentary. In general, all the Pennsylvanian rocks in southern Illinois below the Battery Rock Sandstone are assigned to either the Lusk Shale or the Wayside Sandstone.

**Wayside Sandstone Member**—The Wayside Sandstone Member of the Caseyville Formation (Lamar, 1925, p. 84-85) is named for Wayside, Johnson County, and the type section consists of outcrops near the village (N $\frac{1}{2}$  30, 11S-2E) (Wanless, 1956, p. 9). The Wayside is the lowermost unit of the Pennsylvanian System on the western side of the southern Illinois outcrop belt and is equivalent, at least in part, to the Lusk Shale to the east. Like the Lusk, it is a complex unit of interbedded lenticular sandstones as much as 50 feet thick that are separated by silty or sandy shales and siltstones, all part of a fluvial-deltaic complex. In the area south of Carbondale the thickness of the Wayside varies but averages about 70 feet.

**Battery Rock Sandstone Member**—The Battery Rock Sandstone Member of the Caseyville Formation (Cox, 1875, p. 204) is named for Battery Rock, a bluff of massive sandstone on the west bank of the Ohio River in Hardin County, the type section (26, 11S-10E). The Battery Rock Sandstone, a prominent bluff-forming unit (fig. P-3A), is very well developed in Gallatin, Hardin, and Pope Counties, where it is 50-100 feet thick in a large area. It is also as much as 100 feet thick in the western part of the southern Illinois outcrop belt, but there it is more lenticular. Along the southwestern side of the Illinois Basin, the sandstone extends only as far north as Randolph County. In the subsurface to the north and northeast of the outcrop belt, the Battery Rock is difficult to trace because several other thick sandstone units occur in the



Fig. P-11—Thickness of the Carbondale Formation (based on map by K. E. Clegg).



Fig. P-10—Combined thickness of the Caseyville, Abbott, and Spoon Formations (after Wanless, 1955).

lower part of the McCormick Group. The Battery Rock is generally medium-grained sandstone, but at places it becomes coarse; almost everywhere it contains scattered quartz granules and pebbles, which in places form conglomerate beds. Although the Caseyville sandstones have been called conglomerates, the term "conglomeratic" is more appropriate. The Battery Rock is correlated with the lower Caseyville conglomerate, or Kyrock Sandstone Member, of western Kentucky and with the lower part of the Mansfield Sandstone of Indiana.

**Drury Shale Member**—The Drury Shale Member of the Caseyville Formation (Lamar, 1925, p. 91-95) is named for Drury Creek in Jackson County, and the type section consists of exposures along the creek south of Makanda (33, 34, 10S-1W). The Drury is a complex unit of sandy or silty shale, siltstone, and lenticular massive sandstone units, and is much like the Lusk Shale. It contains at least two thin, nonpersistent coals. The Drury is as much as 100-150 feet thick in places near the type area, but the thickness varies somewhat, partly because of differential erosion prior to deposition of the overlying Pounds Sandstone. All strata lying between the Battery Rock and Pounds Sandstones are considered equivalent to the Drury, but, for the sake of clarity in classification, the name "Drury" is not used in parts of southeastern Illinois where two other members of the Caseyville Formation—the Sellers Limestone and the Gentry Coal—occur within the Drury interval. Although rocks of Drury age are present in the subsurface of the southern part of the Illinois Basin, the Battery Rock and Pounds Sandstones cannot generally be differentiated in well logs, which makes it impractical to differentiate the Drury. The Drury is equivalent to part of the Mansfield Sandstone of Indiana.

**Sellers Limestone Member**—The Sellers Limestone Member of the Caseyville Formation (Wanless, 1939, p. 36, 101) is named for Sellers Landing, Hardin County, on the west bank of the Ohio River, near the type section (21, 11S-10E) (Wanless, 1956, p. 9). The Sellers Limestone is known only at the type locality, where about 10 feet is exposed. It is a major marine deposit in a complex fluvial-deltaic sequence. Part of the limestone is sandy and coarse grained and contains a varied marine fauna, but most of the Sellers is composed of beds of very fine-grained, argillaceous limestone interbedded with gray shale. No fusulinids, ostracodes, or conodonts have been found in the Sellers. It is equivalent to part of the Drury Shale, but no limestone correlatives are known.

**Gentry Coal Member**—The Gentry Coal Member of the Caseyville Formation (Kosanke et al., 1960, p. 29) is named for Gentry Landing, Hardin County, and the type locality consists of exposures near the landing (SW 26, 11S-10E). It previously was called the Battery Rock Coal (Owen, 1856, No. 1 vertical section). The Gentry Coal has been identified as a thin coal in several scattered localities in southeastern Illinois but is apparently not persistent. It was mined more than 100 years ago in small mines near the settlement of Lamb in Hardin County. It is underlain by a thin underclay, which overlies a thick, gray, silty shale that is equivalent to part of the Drury Shale. It is overlain by a shale that also is equivalent to part of the Drury Shale. Its exact relation to the Sellers Limestone has not been established, although field relations suggest that the Gentry is slightly above the Sellers.

**Pounds Sandstone Member**—The Pounds Sandstone Member of the Caseyville Formation (Weller, 1940, p. 38), the uppermost member, is named for Pounds Hollow in Galatin County, and the type section consists of exposures along the hollow (35, 36, 10S-8E). The Pounds Sandstone is lithologically similar to the Battery Rock Sandstone and reaches 100 feet thick, forming long, abrupt bluffs in southern Illinois, usually north of the Battery Rock bluff. The Pounds is also known as far north as Rock Castle Creek in Randolph County (33, 6S-5W). Like other members of the Caseyville Formation, the Pounds Sandstone has not been widely traced in the subsurface north of the outcrop belt, although strata of this age and lithologic character are known to be present (fig.

P-9). The Pounds is correlated with part of the Mansfield Sandstone of Indiana and the upper Caseyville conglomerate, or Bee Springs Sandstone Member, of western Kentucky.

## ATOKAN SERIES

The Atokan Series of the Pennsylvanian System (Taff and Adams, 1900, p. 273) is named for Atoka, Atoka County, Oklahoma. No type section was designated, but the area near Atoka contains a sequence of a few thousand feet of sandstones and shales generally devoid of invertebrate fossils and truncated at the top by a major fault. In Illinois the Atokan Series consists of the strata composing the Abbott Formation of the McCormick Group (Willman et al., 1967) (fig. P-2). The base and top have not been defined by fossils, although fossiliferous zones are present within the series.

Where marine rocks are abundant, the Atokan is generally characterized as the two subzones of the earliest fusiform fusulinids, *Profusulinella* and *Fusulinella*, and the top is defined as the strata below the first appearance of *Fusulina* and *Wedekindellina*, although some confusion has arisen because *Fusulina* has been reported in the Atokan of the type area.

Plant fossil zones for the Atokan Series are Zones 7 (*Megatopteris* spp.) and 8 (*Neuropteris tenuifolia*) of Read and Mamay (1964). Spore assemblages are the best means for correlating the Atokan strata in the Illinois Basin with Atokan strata of other areas. They are of greater diversity and their genera are more abundant and more evenly distributed than is true in the Morrowan Series. *Laevigatosporites*, *Calamites*, *Florinites*, and *Punctatisporites* increase in the upper part at the expense of *Lycospora*, which, with *Densosporites*, especially *D. annulatus*, and *Cristatisporites indignibundus*, is common in the lower part of the Atokan. Certain species of *Radiizonates* and *Torispora* are useful in defining the upper part.

## Abbott Formation

The Abbott Formation of the McCormick Group (Kosanke et al., 1960, p. 30, 44) is named for Abbott Station on the Illinois Central Gulf Railroad, Pope County, along which the type section is exposed (5, 6, 7, 18, 19, 11S-5E). The Abbott Formation overlies the Caseyville and extends from the top of the Pounds Sandstone Member to the top of the Bernadotte Sandstone Member of western Illinois, which has been correlated with the Murray Bluff Sandstone Member of southern Illinois (fig. P-2). In subsurface, both the top and base of the Abbott are commonly difficult to determine. Only the sandstones and some

of the coals have been named. In southern Illinois the Abbott overlaps the Caseyville Formation northward and is the basal formation of the Pennsylvanian System throughout most of the state outside the area of Caseyville strata. The Abbott is overlain by the Spoon Formation, which overlaps it in northern and northeastern Illinois and on some prominent anticlinal structures. The Abbott Formation has a maximum thickness of 300-350 feet in southern Illinois, but in western Illinois even where it is well developed it is generally less than 100 feet thick. It is similar to the Caseyville Formation in being composed primarily of detrital rocks, but it differs from the Caseyville in containing thicker, more widespread coals and in the character of the sandstones. The sandstones in the Abbott are generally finer grained, thinner in maximum development, contain more interstitial clay and mica flakes, and have no more than a few quartz granules and pebbles. These characteristics are transitional; the lower sandstones in the Abbott more closely resemble those in the Caseyville and the upper are similar to the impurer sandstones of the overlying Spoon Formation. Abbott shales are similar to those of the Caseyville but are in general less sandy. About half of the formation is shale; no named limestone units occur in the Abbott Formation. Calcareous sandstones, sandy limestones, and a few shale units contain marine fossils locally. Two marine limestones in southwestern Indiana (the Fulda and Ferdinand Members) and the Lead Creek Limestone Member in western Kentucky occur in strata equivalent to the lower part of the Abbott Formation in Illinois, as the associated coal floras show. The Abbott Formation is equivalent to the uppermost part of the Caseyville Formation and the lower part of the Tradewater Formation in western Kentucky and to the upper part of the Mansfield and essentially all of the Brazil Formation in Indiana.

**Reynoldsburg Coal Member**—The Reynoldsburg Coal Member of the Abbott Formation (Weller, 1940, p. 39), the lowermost named member in southern Illinois, is named for Reynoldsburg, Johnson County, and the type locality is north of Cedar Creek (W1/2 32, 11S-4E). The Reynoldsburg is well known only in a relatively small area in the central part of the southern Illinois outcrop belt, where the thickness of the coal is very irregular but is as much as 3 feet. It varies in character, apparently grading to a cannelloid black shale near the type locality. The Reynoldsburg Coal has been mined locally in the type area. It is well exposed along Interstate 24 in the northernmost of a series of large highway cuts, which exposes all the Caseyville Formation and the lowermost part of the Abbott Formation. No coal at this position has been identified in western Illinois, but the No. 2 coal in western Kentucky is thought to be equivalent to the Reynoldsburg.

**Grindstaff Sandstone Member**—The Grindstaff Sandstone Member of the Abbott Formation (Butts, 1925, p. 44) is named for Grindstaff Hollow in Gallatin County, and outcrops along the hollow (NE cor. 28, 10S-8E) are the type section. The Grindstaff is similar in appearance and characteristics to the other two sandstones of the Abbott Formation in southern Illinois. It is best developed east of the Du Quoin Monocline. The Grindstaff is generally fine or medium grained, most of it is slightly micaceous, and it varies considerably in thickness up to 60 feet. It sometimes contains quartz granules and pebbles in the western part of the southern Illinois outcrop belt but generally fewer than occur in the underlying Caseyville sandstones. The sandstone is thickest and coarsest where it was deposited in local distributary or fluvial channels. It grades laterally into and overlies gray, silty or sandy shale. In a few places a very impure, sandy, clastic limestone or calcareous sandstone, formerly called the Boskydell Marine Zone or Boskydell Sandstone, is found at or near

the position of the Grindstaff Sandstone in southwestern Illinois. The Grindstaff Sandstone is correlated with the Babylon Sandstone of western Illinois.

**Babylon Sandstone Member**—The Babylon Sandstone Member of the Abbott Formation (Wanless, 1931a, p. 189-190, 192-193), the lowest named member in western Illinois, is named for Babylon, Fulton County. The type locality is half a mile north of Babylon in the west bank of the Spoon River (NE NE 14, 7N-1E) (Wanless, 1957, p. 65, 205). The Babylon Sandstone is widely present in western Illinois and at its maximum is about 25 feet thick. In many places it is the lowest unit of the Pennsylvanian System and unconformably overlies Mississippian limestones. The sandstone is made up of relatively pure, subangular, medium to coarse quartz grains, most of which have been secondarily enlarged by quartz overgrowths that sparkle in sunlight (Wanless, 1957). The Babylon in western Illinois becomes thinner and sporadic in occurrence to the south. It is correlated with the Grindstaff Sandstone of southern Illinois.

**Manley Coal Member**—The Manley Coal Member of the Abbott Formation (Kosanke et al., 1960, p. 31) is named for Manley, Fulton County. It previously was called the Babylon Coal (Wanless, 1931a, p. 189-190, 192-193). It shares the type locality of the Babylon Sandstone Member (Wanless, 1957, p. 66, 205). The Manley Coal is widely distributed in western Illinois but occurs sporadically. It ranges up to 4 feet thick and has been mined in a few places. It varies from banded coal to cannel coal, and at one mine in Fulton County cannel coal 2.5-3 feet thick was once mined (Wanless, 1957). The Manley has not been identified in southern Illinois. It is correlated with the Shady Lane Coal Member of Indiana.

**Willis Coal Member**—The Willis Coal Member of the Abbott Formation (Butts, 1925, p. 62-63) is named for the Willis Mine in Gallatin County (SE SW 30, 10S-9E). The coal is present at widely scattered localities in the outcrop area in southern Illinois. It has been mined locally in southeastern Illinois, where it is 3-3.5 feet thick. In the type area the Willis is closely underlain by the Grindstaff Sandstone Member and is immediately overlain by about 40 feet of Finnie Sandstone. It is correlated with the Tarter Coal of western Illinois and the Lower Block Coal Member of Indiana.

**Tarter Coal Member**—The Tarter Coal Member of the Abbott Formation (Wanless, 1939, p. 15, 103) is named for Tarter Bridge over the Spoon River, Fulton County, and the type section consists of exposures near the bridge (SE 2, 5N-1E) (Wanless, 1956, p. 9; 1957, p. 67, 202). The Tarter Coal is thin and discontinuous throughout its outcrop area in western Illinois (Wanless, 1957), attaining a maximum thickness of slightly over 1 foot in many scattered outcrops. The interval from the Tarter Coal up to the Pope Creek Coal is usually only a few feet, and both coals are present in several outcrops. The Tarter is correlated with the Willis Coal of southern Illinois and the Lower Block Coal Member of Indiana.

**Finnie Sandstone Member**—The Finnie Sandstone Member of the Abbott Formation (Owen, 1856, No. 1 vertical section) is named for Finnie Bluff at the type locality, which is "along road for less than 2 miles north of Mulfordtown, Union County, Kentucky" (Glenn, 1912, p. 14). "Finnie" was adopted in Illinois to replace "Delwood Sandstone" (Kosanke et al., 1960, p. 31). The Finnie is widespread throughout much of southern Illinois east of the Du Quoin Monocline. Its bedding varies widely, as does its thickness (up to 60-70 feet). It is similar in appearance to other sandstones in the Abbott Formation and in a few localities contains scattered marine fossils. The distribution of the Finnie in the deeper part of the Illinois Basin has not been determined.

**Delwood Coal Member**—The Delwood Coal Member of the Abbott Formation (Weller, 1940, p. 40) is named for Delwood, Pope County, and the type locality consists of exposures near the village (NW NW 3, 11S-6E) (Wanless, 1956, p. 9). The Delwood Coal has been identified in several wide-

ly scattered outcrops in southern Illinois and in places is more than 3 feet thick. It is probably not continuous and locally may have been removed by channeling during development of a younger sandstone. Very little is known of the distribution of the Delwood in subsurface north of the outcrop belt. The name may have been applied to more than one coal and, in fact, recent palynological studies indicate the type Delwood may be equivalent to the Bidwell Coal Member of the lower part of the Spoon Formation. The Delwood has been correlated with the Pope Creek Coal of western Illinois, the Upper Block Coal Member of Indiana, and the No. 3 (Ice House) coal of western Kentucky.

**Pope Creek Coal Member**—The Pope Creek Coal Member of the Abbott Formation (Wanless, 1931a, p. 189-190, 192) is named for Pope Creek in Mercer County, and the type locality is along the creek (cen. 33, 14N-2W) (Wanless, 1929, p. 52; 1956, p. 9). The Pope Creek Coal is widespread in the western Illinois outcrop belt, where it is as much as 3 feet thick and averages about 1 foot (Wanless, 1957). The upper part of the coal is truncated in places by the Bernadotte Sandstone, but more commonly the coal is overlain by a gray shale several feet thick. The Pope Creek has been correlated with the Delwood Coal of southern Illinois, the Upper Block Coal Member of Indiana, and the No. 3 (Ice House) coal of western Kentucky.

**Bernadotte Sandstone Member**—The Bernadotte Sandstone Member (Savage, 1927, p. 307-316), which forms the top of the Abbott Formation in western Illinois, is named for the former town of Bernadotte, Fulton County, near the type locality (SW 19, 5N-2E) (Wanless, 1956, p. 9; 1957, p. 70-72, 103). The Bernadotte Sandstone is fairly extensive in western Illinois and attains thicknesses of 18 feet, though it commonly averages about 5 feet. It is very fine grained, only slightly micaceous, and the upper part is commonly cemented with silica. The Bernadotte differs from most Pennsylvanian sandstones in generally having a flat base and an uneven top, on the thicker parts of which overlying stratigraphic units tend to wedge out (Wanless, 1957). The Bernadotte is correlated with the Murray Bluff Sandstone of southern Illinois.

**Murray Bluff Sandstone Member**—The Murray Bluff Sandstone Member of the Abbott Formation (Weller, 1940, p. 40), the top member of the formation in southern Illinois, is named for the hill called Murray Bluff in Saline County, where the type section occurs (NE 35, 10S-5E). In the type section the sandstone is at least 60 feet thick and contains many liesegang rings (secondary iron-oxide diffusion banding). It is relatively thick in channel facies and thinner in nonchannel facies. The Murray Bluff has been identified at numerous localities throughout the outcrop area in southern Illinois, but its northward extent in the subsurface is generally not recognized. A sandstone occurs at this position in the areas where the Litchfield and Assumption Coals of the Spoon Formation are present. The Murray Bluff has been correlated with the Bernadotte Sandstone of western Illinois and the Aberdeen Sandstone Member of western Kentucky.

## DESMOINESIAN SERIES

The Desmoinesian Series of the Pennsylvanian System (Keyes, 1893, p. 86-114) is named for the Des Moines River in Iowa, along which the strata of the series are exposed. No specific type section was designated. In Illinois the Desmoinesian includes all of the Spoon and Carbondale Formations of the Kewanee Group and the lower part of the Modesto Formation of the McLeansboro Group—up to the top of the Trivoli Sandstone Member (Willman et al., 1967) (fig. P-2).

The Desmoinesian is the most widely developed series of the Pennsylvanian in the United States.

Fusulinids are abundant in many of the limestones in Illinois (Dunbar and Henbest, 1942), and the Desmoinesian is the *Fusulina* Zone. That genus is confined to the Desmoinesian Series, except for the one reported occurrence in Atokan rocks. Several other invertebrates, such as *Mesolobus*, *Chaetetes*, and *Prismopora*, are seldom found above the top of the Desmoinesian, and certain of their species are confined to this series. The exact upper boundary is difficult to determine in much of the Illinois Basin because an interval at the top of the Desmoinesian and the base of the Missourian is barren of fusulinids.

Floral Zones 9 (*Neuropteris rarineris*) and 10 (*Neuropteris flexuosa* and *Pecopteris* spp.) of Read and Mamay (1964) are included in the Desmoinesian Series. In Illinois the series contains the thickest, most widespread coals, the spores of which are dominated by *Lycospora*. That genus suddenly disappears at the top of the Desmoinesian. *Thymospora pseudothiessenii*, which appears in the bottom third, also disappears at the top of the Desmoinesian. *Densosporites* occurs only in the lower half of the Desmoinesian, and *Schopfites* is diagnostic of approximately the middle third. There is a marked change in the spore flora at the Desmoinesian-Missourian boundary.

## Kewanee Group

The Kewanee Group (Kosanke et al., 1960, p. 31) is named for Kewanee, Henry County, in western Illinois in the outcrop belt of its two formations—Spoon and Carbondale (fig. P-2). It includes strata previously classified as the Carbondale Formation or Group plus older and younger strata (P-5). The Kewanee Group is continuously recognized in all of the Illinois Basin within the confines of its outcrop limits. It normally lies above the Abbott Formation, but in northern and northeastern Illinois where the Abbott is missing it lies on rocks ranging in age from Valmeyeran (middle Mississippian) to Champlainian (middle Ordovician). It is overlain by the McLeansboro Group. The Kewanee Group contains the best developed cyclothems and more than 99 percent of the mapped coal reserves of the state (Cady et al., 1952). Lateral continuity of many of the lithologic units, especially the marine limestones, black fissile shales, coals, and underclays is remarkably extensive. The

limestones, generally less than 5 feet thick, were deposited during marine transgressions from the west and southwest. Along with marine shales they alternate with fluvial and deltaic sediments that include siltstones, silty shales, elongate "channel" sandstones, and coals. The limestones are usually gray and argillaceous, and they contain a diverse marine fauna dominated by brachiopods, gastropods, crinoids, pelecypods, and Foraminifera (including fusulinids). The sandstones are texturally and mineralogically less mature than those of the McCormick Group in that they contain much more clay matrix, mica flakes, and feldspar grains, and their sand grains are less rounded and not as well sorted.

### *Spoon Formation*

The Spoon Formation of the Kewanee Group (Kosanke et al., 1960, p. 32, 45) is named for the Spoon River, Fulton County, about a quarter of a mile east of the type section, which is in a roadcut and a railroad cut (NE SE 22, 6N-1E). The formation consists of strata from the top of the Bernadotte Sandstone of western Illinois or the Murray Bluff Sandstone of southern Illinois to the base of the Colchester (No. 2) Coal (fig. P-2), rocks formerly included in the upper part of the Tradewater Group. The Spoon Formation is present throughout most of the area in which Pennsylvanian strata occur. It is as much as 350 feet thick in southern Illinois but ranges from a few feet to less than 100 feet in northern and western Illinois. The formation is characterized by less sandstone and more coal and limestone than the Abbott Formation below and by less limestone and coal than the Carbondale Formation above. Sandstones are well developed in both elongate and sheet facies but do not constitute as much of the total section as they do in the lower formations. The sandstones show the general upward increase in the amount of argillaceous matrix and mica flakes that began in the sandstones in the Abbott Formation, from which they differ only slightly. The formation contains the first widespread limestones and coals, but they are thinner than those in the younger Pennsylvanian of Illinois. The coals of the Spoon are thicker and more extensive than those of the lower formations. The Spoon Formation correlates with the upper part of the Tradewater Formation and the lower part of the Carbondale Formation in western Kentucky and the very uppermost part of the Brazil Formation, all the Staunton Formation, and the lower part of the Linton Formation in Indiana.

**Rock Island (No. 1) Coal Member**—The Rock Island (No. 1) Coal Member of the Spoon Formation is the basal named member of the formation in western Illinois. It was first called Coal Number 1 (Worthen, 1868, p. 6, 10, 11) because it was believed to be the oldest (the first deposited) minable coal in Fulton, Morgan, Scott, and Schuyler Counties. It is typically exposed in the Spoon River Bluff near Seville, Fulton County (Worthen, 1870, p. 194). This exposure was designated the type section (SW SW 23, 6N-1E) by Wanless (1957, p. 72, 201). As that coal was correlated with the coal mined at Rock Island (Worthen and Shaw, 1873, p. 221, 229-232), the name Rock Island (No. 1) Coal came into general use. In western Illinois the Rock Island (No. 1) Coal

occurs only in widely scattered areas. It attains a maximum thickness of about 8 feet in belts trending east-west or north-east-southwest (Wanless, 1965, p. 27, 29-30; Searight and Smith, 1969, p. 13), in other places only a few inches to a foot or two of coal is present, and it is absent throughout broad areas. The Rock Island Coal is tentatively correlated with the Assumption and the Litchfield Coals of west-central Illinois. It has been correlated with the Murphysboro Coal (Wanless, 1957), but the floras indicate it is lower than the Murphysboro (Kosanke, 1950). It is correlated with the Minshall Coal Member of Indiana.

**Litchfield Coal Member**—The Litchfield Coal Member of the Spoon Formation (Kay, 1915, table 9 and footnote, p. 139) is named for Litchfield, Montgomery County, where the coal was mined at a depth of 684 feet in the Litchfield Collieries Company Mine No. 7, which is the type section (SE NE NE 32, 9N-5W). In the mine, the Litchfield Coal occurs about 150 feet below the Lowell Coal and is 2-7 feet thick. It is not widely recognized throughout southern Illinois but has been found in a few drill holes. The Litchfield Coal is probably equivalent to the lower bench of the Assumption Coal and to the Rock Island (No. 1) Coal.

**Assumption Coal Member**—The Assumption Coal Member of the Spoon Formation (Cady, 1935, p. 53) is named for Assumption, Christian County, where the coal was mined at a depth of 1002 feet in the long-abandoned Assumption Coal and Mining Company Mine, which is the type section (NE NW SE 2, 12N-1E). In the mine the coal was 3-4 feet thick and was commonly split into 2 benches. In part of the mine the coal was overlain by limestone correlated with the Seville Limestone, which overlies the Rock Island Coal. The two benches were within 2 feet of each other in some parts of the mine. Where the coal seam was more widely split, the limestone formed the roof of the lower bench, and the interval to the upper bench, as much as 25 feet, consisted of sandstone and carbonaceous shale. The lower bench is the Assumption Coal Member. The extent of the Assumption Coal has not been ascertained, but a coal at approximately this position has been encountered in a few borings scattered throughout the Illinois Basin. The lower of the two benches is tentatively correlated with the Litchfield Coal of southwestern Illinois and the Rock Island (No. 1) Coal of western Illinois.

**Seville Limestone Member**—The Seville Limestone Member of the Spoon Formation (Wanless, 1931a, p. 189, 192) is named for Seville, Fulton County, where the type locality is in the southwest bank of the Spoon River (SW SW 23, 6N-1E) (Wanless, 1956, p. 9; 1957, p. 72-73, 201). The Seville Limestone is dark gray and argillaceous, and it contains a well preserved and diverse marine fauna. It is sporadic in occurrence and varies in thickness. It is seldom more than 4 feet thick, but more than 30 feet has been reported near Cuba, Fulton County. In several quarries in Rock Island and Mercer Counties, thicknesses up to 16 feet occur. The thicker occurrences are in narrow belts believed to have been estuaries, and in those areas the underlying Rock Island (No. 1) Coal is also thicker than elsewhere. The Seville Limestone is correlated with the Curlew Limestone Member of western Kentucky, the Lower Mercer Limestone of Ohio and Pennsylvania, and the Verne Shaly Limestone Member of Michigan (Wanless, 1957, p. 73). The name "Seville" has also been applied to this limestone in Missouri and Oklahoma.

**Curlew Limestone Member**—The Curlew Limestone Member of the Spoon Formation (Owen, 1856, No. 1 vertical section) is named for Curlew, Union County, Kentucky, where the type locality is an exposure on Indian Hill (Glenn, 1912, p. 24). The Curlew is gray, fine-grained, locally cherty limestone that seldom is more than 4 feet thick. It contains an abundant open-marine fauna. It is widespread, though sporadic, in southern Illinois and western Kentucky. The Curlew is correlated with the Seville Limestone.

**Hermon Coal Member**—The Hermon Coal Member of the Spoon Formation (Kosanke et al., 1960, p. 33) is named for Hermon, Knox County. The unit formerly was called the Lower De Long Coal (Wanless, 1931a, p. 188-192). The type locality is along Brush Creek in Knox County, where the Hermon is the lowest of three thin coals (6, 8, 9N-2E) (Wanless, 1956, p. 9; 1957, p. 73-74). The Hermon Coal is found in many parts of western Illinois but is discontinuous. At most places it is represented by 2 inches or less of carbonaceous shale or bony coal. Near Canton in Fulton County, where it occurs locally over thick Rock Island Coal and thick Seville Limestone, the coal is as much as 4 feet thick. It is generally underlain by as much as 4 feet of gray underclay. No coal equivalent to the Hermon Coal has been recognized in southern Illinois.

**Bidwell Coal Member**—The Bidwell Coal Member of the Spoon Formation (Kosanke et al., 1960, p. 32, 65) is named for Bidwell School in Johnson County, which is near the type locality (NE SE SW 5, 11S-4E). The Bidwell Coal, although discontinuous, is more widespread than most of the coals in the lower part of the Spoon Formation in southern Illinois and is 4 feet thick in places, although generally thinner. It has been identified in only a few drill holes north of the outcrop belt. The Bidwell has not been recognized in western Illinois.

**O'Nan Coal Member**—The O'Nan Coal Member of the Spoon Formation (Kosanke et al., 1960, p. 32) is named for Dennis O'Nan Ditch, which flows across the tip of Indian Hill, Union County, Kentucky, the type locality (Glenn, 1912, p. 25). It previously was called the Curlew Coal (Owen, 1856, p. 47). The O'Nan Coal is generally thin, seldom over 1 foot thick in its scattered occurrences in southern Illinois. It is now believed to be equivalent to the Bidwell Coal.

**New Burnside Coal Member**—The New Burnside Coal Member of the Spoon Formation (Weller, 1940, p. 42) is named for New Burnside, Johnson County, which is near the type locality (SE SE SW 5, 11S-4E) (Kosanke et al., 1960, p. 32). The New Burnside Coal is well developed in scattered localities in southern Illinois and is as much as 5 feet thick where mined; however, in most of the area it is generally thinner. It occurs 15-25 feet above the Bidwell Coal. The New Burnside is correlated with the Brush Coal of western Illinois.

**Brush Coal Member**—The Brush Coal Member of the Spoon Formation (Kosanke et al., 1960, p. 33) is named for Brush Creek, Knox County, where it is the middle of three thin coals. It previously was called the Middle De Long Coal (Wanless, 1931a, p. 188-192). The type locality is along the creek (6, 8, 9N-2E) (Wanless, 1956, p. 9; 1957, p. 74-75). The Brush Coal, widely recognized in western Illinois, consists primarily of carbonaceous shale or bony coal only a few inches thick, which is generally overlain by the underclay of the De Long Coal and underlain by a very persistent, purplish gray underclay that is commonly 3-5 feet thick. The Brush Coal is correlated with the New Burnside Coal of southern Illinois.

**Cheltenham Clay Member**—The Cheltenham Clay Member of the Spoon Formation (Wheeler, 1896, p. 247; White, 1909, p. 293) is named for the Cheltenham district in the southern part of St. Louis, Missouri. In Illinois, the name is applied locally to a complex claystone member that results from the thinning out of many units and the merging of several underclay units. The stratigraphic interval occupied by this member varies. The youngest deposits are at or immediately below the underclay of the Colchester (No. 2) Coal and the oldest are near the base of the underclay below the Brush (New Burnside) Coal. The Cheltenham is developed primarily in northern, western, and southwestern Illinois, areas where the Pennsylvanian section below the Colchester Coal is relatively thin. The Cheltenham Clay Member in Illinois is considered to be part of the Desmoinesian Series, but in Missouri

similar deposits (Cheltenham Formation) are considered part of the Atokan Series (Howe and Koenig, 1961).

**Granger Sandstone Member**—The Granger Sandstone Member of the Spoon Formation (Kosanke et al., 1960, p. 32) is named for Grangertown, near Indian Hill, Union County, Kentucky, the type locality (Glenn, 1912, p. 24-26). It was originally called the Curlew Sandstone (Owen, 1856, No. 1 vertical section). The Granger Sandstone is widespread in southern Illinois, occurring in channel and nonchannel facies and varying considerably in thickness and bedding characteristics. About 40 feet of Granger Sandstone is well exposed in the Creal Springs Quarry in Williamson County (25, 10S-3E). The sandstone is probably present in much of the deeper part of the Illinois Basin.

**Murphysboro Coal Member**—The Murphysboro Coal Member of the Spoon Formation (Worthen, 1868, p. 11-12) is named for Murphysboro, Jackson County, where the type locality is in mines (SE 9, 9S-2W) (Wanless, 1956, p. 9). The Murphysboro Coal is well developed only in Jackson County and western Williamson County, where it has been reported to be locally more than 7 feet thick. In places it occurs in several benches separated by shale (Shaw and Savage, 1912). Mining started in this area around 1810, and the coal was sent to New Orleans in flatboats via the Big Muddy and Mississippi Rivers. Where the Murphysboro Coal is thick it is overlain by 40 or more feet of gray silty shale. In these areas the coal contains much less sulfur than elsewhere and resembles the Herrin (No. 6) and Harrisburg (No. 5) Coals, which also have low-sulfur contents where they have thick roof shales. Where relatively thin, the Murphysboro Coal contains much more sulfur, chiefly in the mineral pyrite. In early reports the Murphysboro Coal was correlated with the Colchester (No. 2) Coal, but its position was later found to be lower (Wanless and Weller, 1932), and it is now known to be between the No. 1 and No. 2 Coals.

**Creal Springs Limestone Member**—The Creal Springs Limestone Member of the Spoon Formation (Kosanke et al., 1960, p. 32, 64, 65) is named for Creal Springs, Williamson County. The type section consists of exposures in the sandstone quarry east of Creal Springs (NE SE SE 25, 10S-3E). The Creal Springs Limestone is gray, argillaceous, and in places cherty. It is seldom over 2 feet thick and contains an open-marine fauna. In the type area the Creal Springs lies on the Granger Sandstone, but throughout much of its extent it is separated from the underlying Murphysboro Coal by several feet of gray shale. The Creal Springs is lenticular and occurs sporadically in a large part of southern Illinois. In some places it was once correlated with the Curlew Limestone, but the fusulinids it contains indicate it is younger than the Curlew (Thompson et al., 1959).

**Mt. Rorah Coal Member**—The Mt. Rorah Coal Member of the Spoon Formation (Kosanke et al., 1960, p. 33) is named for Mt. Rorah Church, which is about 2 miles north of the type locality (SE 25, 10S-4E; erroneously listed as section 35 in Wanless, 1956, p. 9, and Kosanke et al., 1960, p. 45). It previously was called the Bald Hill Coal (Cady, 1926, p. 259-260). The Mt. Rorah Coal occurs sporadically in a large part of southern Illinois, but it is seldom over 2 feet thick, generally no more than a few inches. It is correlated with the De Long Coal of western Illinois.

**De Long Coal Member**—The De Long Coal Member of the Spoon Formation (Wanless, 1931a, p. 188-192), named for De Long, Knox County, is the uppermost of three thin coals that crop out about 1 1/2 miles southwest of De Long along Brush Creek, the type locality (6, 8, 9N-2E) (Wanless, 1956, p. 9; 1957, p. 188-192). It was called the Upper De Long Coal until "De Long," which had been applied to three coals, was restricted to the uppermost coal (Kosanke et al., 1960, p. 33). The De Long Coal is widespread in western Illinois but is not known to be more than a few inches thick. It

is commonly made up of two thin coal seams separated by as much as 2 feet of claystone. The coal is separated from the overlying Seahorne Limestone by soft, poorly laminated shale 1-15 feet thick, and from the underlying Brush Coal by 1-3.5 feet of claystone and, commonly, a few inches of soft, light gray shale immediately over the Brush Coal. The De Long Coal is correlated with the Mt. Rorah Coal of southern Illinois.

**Wise Ridge Coal Member**—The Wise Ridge Coal Member of the Spoon Formation (Kosanke et al., 1960, p. 33) is named for Wise Ridge, a hill about 3 miles west of the type section—a roadcut in Stonefort, Williamson County (NE SE 25, 10S-4E). It previously was called the Stonefort Coal (Wanless, 1939, p. 30, 103). The coal is lenticular but is widely present in southern Illinois. It is generally less than 3 feet thick and is very thin at some places. It is commonly separated from the Stonefort Limestone (above) by 1-2 feet of black fissile shale.

**Stonefort Limestone Member**—The Stonefort Limestone Member of the Spoon Formation (Henbest, 1928, p. 70-71) is named for Stonefort, Williamson County. The type locality consists of a roadcut and near-by ravines (NE SE 25, 10S-4E), a correction of the location given by Wanless (1956, p. 9) (Kosanke et al., 1960, p. 33). The Stonefort is a gray, fine-grained, marine limestone, seldom over 3 feet thick, that extends throughout the greater part of southern Illinois. It has been identified on geophysical logs of oil tests in much of the southern part of the Illinois Basin.

**Vergennes Sandstone Member**—The Vergennes Sandstone Member of the Spoon Formation (Shaw and Savage, 1912, p. 7) is named for Vergennes, Jackson County, and the type locality is near the town (N $\frac{1}{2}$  11, 7S-3W). The outcrops indicate that the Vergennes is a channel sandstone at least 30 feet thick, but units above and below it are poorly exposed and its stratigraphic position is in question. The name Vergennes has not been extended beyond the type area, and recent studies by T. K. Searight suggest that the Vergennes may be equivalent to the Palzo Sandstone.

**Seahorne Limestone Member**—The Seahorne Limestone Member of the Spoon Formation (Wanless, 1931a, p. 191) is named for Seahorne Branch in Fulton County, and the type section consists of exposures along that stream (S $\frac{1}{2}$  SE 5, 3N-3E) (Wanless, 1956, p. 9; 1957, p. 76, 200). The Seahorne is best known in western Illinois, where it varies from limestone nodules in claystone to a solid ledge of limestone more than 6 feet thick. It is usually light gray. In some places it is conglomeratic or brecciated and consists of dark gray fragments that contain abundant brachiopods embedded in a light gray matrix that is dominated by a diverse gastropod fauna. Another fauna, *Spirorbis* and ostracodes, is found at places and is generally considered nonmarine. The Seahorne is not persistent but occurs at many places in Illinois and adjacent states. It is the caprock of the Tebo coal in Missouri (Wanless, 1957).

**Davis Coal Member**—The Davis Coal Member of the Spoon Formation (Owen, 1856, p. 41) is named for the Davis Mine, located half a mile east of Dekoven Station, Union County, Kentucky (Lee, 1916, p. 19, 30). It has also been called the No. 6 coal in western Kentucky. In Illinois the Davis Coal has about the same distribution as the De Koven Coal, which it underlies by as much as 30-40 feet. The Davis averages about 4 feet thick across much of southern Illinois, where it has been mined by surface methods (Butts, 1925). To the north and west the coal, as a rule, is thinner. It is correlated with the Wiley Coal of western Illinois.

**Wiley Coal Member**—The Wiley Coal Member of the Spoon Formation (Wanless, 1931a, p. 191) is named for Wiley School, Fulton County, near the type section (SW NW 16, 7N-2E) (Wanless, 1956, p. 9; 1957, p. 79, 206). The Wiley is a widespread coal in western Illinois. It is seldom more than 2 feet thick, although local occurrences of up to 3 feet are known. It is correlative with the Davis Coal of southern

Illinois and western Kentucky. It may be equivalent to the Mineral coal of Missouri and Kansas (Wanless, 1957).

**De Koven Coal Member**—The De Koven Coal Member of the Spoon Formation (Lee, 1916, p. 30, 31) is named for Dekoven Station, Union County, Kentucky, near which it is well exposed. The De Koven Coal, also called the No. 7 coal in western Kentucky, occurs from a few to about 40 feet above the Davis Coal and is widespread throughout Williamson, Saline, and Gallatin Counties, averaging about 3 feet thick (Butts, 1925). It is also present to the north in the deeper part of the Illinois Basin, but there it is generally thinner. In Williamson County the De Koven Coal is split by a few feet of dark shale. The De Koven is correlated with the Greenbush Coal of western Illinois.

**Greenbush Coal Member**—The Greenbush Coal Member of the Spoon Formation (Wanless, 1931a, p. 191) is named for Greenbush Township, Warren County, the type locality (E $\frac{1}{2}$  24, 8N-1W) (Wanless, 1956, p. 10; 1957, p. 81, 205). The Greenbush Coal is seldom more than a few inches thick, and it grades into a thin carbonaceous shale in some localities. It is correlated with the De Koven Coal of southern Illinois and western Kentucky.

**Seelyville Coal Member**—The Seelyville Coal Member of the Spoon Formation (Kosanke et al., 1960, p. 33; incorrectly spelled "Seeleyville") is named for Seelyville, Vigo County, Indiana, where the type locality is in mines (12N-7 and 8W). It was originally named Indiana Coal III (Ashley, 1899, p. 106-107) but informally called Seelyville in Indiana. In Illinois the Seelyville is known primarily in Edgar, Clark, and Crawford Counties, where it is as much as 6 feet thick. It occurs locally in southern Illinois between the De Koven and Colchester Coals. In Indiana it is now called Seelyville Coal Member (III).

**Palzo Sandstone Member**—The Palzo Sandstone Member of the Spoon Formation (Cady, 1942, p. 9; Weller et al., 1942a, p. 10, footnote) is named for Palzo, Williamson County, and the type locality consists of exposures near the village (SE 16, 10S-4E) (Wanless, 1956, p. 10). The Palzo Sandstone is well developed throughout the state in both channel and nonchannel facies and is locally more than 50 feet thick. It is similar in appearance to other sandstones in the Spoon Formation in southern Illinois and is correlated with the Isabel Sandstone of western Illinois and the Sebree Sandstone Member of western Kentucky.

**Isabel Sandstone Member**—The Isabel Sandstone Member of the Spoon Formation (Wanless, 1931a, p. 192) is named for Isabel Township, Fulton County, which includes the type section (NW NE 16, 4N-3E) (Wanless, 1956, p. 10; 1957, p. 83, 199). The name is used in western Illinois for a sandstone that generally is relatively thin, fine-grained, micaceous, feldspathic, and cemented with various amounts of calcium carbonate. The Isabel and younger sandstones differ from the stratigraphically lower sandstones in western Illinois in that they are less quartzose, contain much more mica and feldspar, are not as well sorted, and do not show the abundant quartz overgrowths that produce the "sparkling sandstones." A sandstone is present at this position essentially throughout Illinois. In southern Illinois it is called the Palzo Sandstone.

**Abingdon Coal Member**—The Abingdon Coal Member of the Spoon Formation (Culver, 1925, p. 75) is named for Abingdon, Knox County, near the type locality (cen. 6, 9N-2E) (Weller et al., 1942b, p. 1589). The Abingdon is recognized only in western Illinois, where it varies in thickness but only locally exceeds 2 feet. It is absent from extensive areas. Although the Abingdon is not definitely recognized in other parts of the state, coals locally present near this position in northern and southern Illinois may be equivalent to the Abingdon Coal.

**Browning Sandstone Member**—The Browning Sandstone Member of the Spoon Formation, the youngest named member (Wanless, 1939, p. 14, 78), is named for Browning

Township, Schuyler County, which includes the type locality (18, 2N-1E) (Wanless, 1956, p. 10; 1957, p. 86). The Browning Sandstone has been recognized only in western Illinois (Wanless, 1957), where it occurs in both channel and sheet facies and ranges from less than 3 to as much as 80 feet thick. In some places the channel facies is almost entirely sandstone that grades upward into shale, but in other places most of it is silty shale and siltstone.

## Carbondale Formation

The Carbondale Formation of the Kewanee Group (Shaw and Savage, 1912, p. 6; Wanless, 1939, p. 79; Willman and Payne, 1942, p. 86-87; Kosanke et al., 1960, p. 34) is named for Carbondale, Jackson County, which lies near the outcrop belt of these rocks. A type section consisting of three outcrops was established in Fulton County, western Illinois (SE NE 1, 7N-4E; NW NE NW 20, 8N-3E; and SW cor. 21, 8N-3E) by Kosanke et al. (1960, p. 34, 46). The Carbondale includes strata from the base of the Colchester (No. 2) Coal Member to the top of the Danville (No. 7) Coal Member (fig. P-2). Shaw and Savage included in the Carbondale the strata from the base of the Murphysboro Coal to the top of the Herrin (No. 6) Coal. The Murphysboro was thought to be equivalent to the Colchester (No. 2) Coal of western Illinois, and the intent was to make the Colchester Coal the base of the formation. Wanless (1939) redefined the Carbondale as a group (fig. P-5), and Willman and Payne (1942) included strata from the base of the Palzo Sandstone to the base of the Anvil Rock Sandstone in the Carbondale Group. The Carbondale Formation consists of a large number of named members, many of which possess remarkable lateral persistence in thickness and lithologic character. In the sandstones and gray silty shales; however, rapid lateral changes are common and are primarily responsible for local and regional changes in thickness. The formation varies from less than 150 feet in western and northeastern Illinois to more than 400 feet near its outcrop belt in southern Illinois (fig. P-11). The Carbondale sandstones occur in elongate, channel facies up to about 100 feet thick and also in thinner sheets. Most of the sandstones are subgraywackes and are more argillaceous than older Pennsylvanian sandstones, although only slightly more so than sandstones of the Spoon Formation. Gray shales are the most abundant type of sediment in Carbondale rocks. Some contain only marine fossils and others only plant fossils. Most of the thicker gray shales probably are either delta front or prodelta deposits. Sideritic nodules and bands are common, especially in the lower parts of the shales. The widespread limestones (fig. P-3B) are gray to dark gray, argillaceous, and normally fossiliferous. Associated with the marine limestones are extensive black fissile shales (fig. P-3C) that are generally less than 2 feet thick and contain marine fossils. Light gray nodular limestones, commonly without fossils, occur in the bottom part of the widespread underclays. The Carbondale Formation contains the principal economic coals of Illinois, the Herrin (No. 6) (fig. P-13), the Springfield-Harrisburg (No. 5) (fig. P-12), the Colchester (No. 2), and the Danville (No. 7) Coal Members, in order of importance as reserves. The Carbondale Formation correlates with the upper portion of the Carbondale Formation and approximately the lower 50 feet of the Sturgis Formation in western Kentucky,

where the boundaries are the base of the Kentucky No. 6 coal and the top of the Kentucky No. 11 coal. Essentially the same interval is called the Carbondale Group in Indiana.

**Colchester (No. 2) Coal Member**—The Colchester (No. 2) Coal Member of the Carbondale Formation, the lowest member, was designated No. 2 by Worthen (1866, p. 59) for the coal in a mine shaft at Highland, Madison County. Worthen also used the name Colchester for the same coal at Colchester, McDonough County (1868, p. 11), and also (1870, p. 96-97) for an exposure 1.5 miles west of Vermont, Fulton County. Wanless (1956, p. 10) designated exposures near Colchester as the type section (12, 13, 5N-4W). The coal has also been called the La Salle (No. 2) Coal or the "Third Vein" coal in northern Illinois. The Colchester Coal is a normal, bright-banded coal (fig. P-3C). It is very extensive in Illinois and is thought to be one of the most widespread coals in the United States. It is generally thin, varying from a fraction of an inch to 18 inches in southern, central, and eastern Illinois, and is rather uniformly 2-3.5 feet thick throughout much of northern and western Illinois, where it has been extensively mined. It is overlain directly by either the black Mecca Quarry Shale Member, or, in parts of western and most of northern Illinois, by the gray Francis Creek Shale Member. It is underlain by a well developed underclay. It is correlated with the Crowburg coal of Missouri and Kansas, the Schultztown of western Kentucky, the Broken Arrow or Crowburg of Oklahoma, the Whitebreast of Iowa, the Colchester Coal Member (IIIa) of Indiana, and tentatively with the Lower Kittanning Coal of the Appalachian field (Wanless, 1957).

**Cardiff Coal Member**—The Cardiff Coal Member of the Carbondale Formation (Cady, 1915) is named for Cardiff, Livingston County, and the type locality is in mines at Cardiff (22, 23, 30N-8E). The name was not in general use until re-introduced by Peppers (1970). The Cardiff Coal is known only in northeastern Livingston, southeastern Grundy, and western Kankakee Counties, where it occurs in channels trending northeast-southwest eroded in gray shale. It generally is not more than 10 feet above the Colchester (No. 2) Coal. At a few localities the Cardiff directly overlies the Colchester Coal. The Cardiff Coal is highly lenticular and was reported in one mine to be 12 feet thick. It commonly is in more than one major bench, the benches separated by gray shale. Peppers (1970) described the flora and concluded that the Cardiff Coal is a little older than the Lowell Coal.

**Francis Creek Shale Member**—The Francis Creek Shale Member of the Carbondale Formation (Savage, 1927, p. 309) is named for Francis Creek in Fulton County and the type locality is along the creek (NE SW 22, 5N-1E) (Wanless, 1929, p. 89; 1956, p. 10; 1957, p. 88, 203). The shale is medium gray, silty, and more than 80 feet thick in northeastern Illinois. It forms a large clastic wedge that extends across the northern part of the area of Pennsylvanian rocks and thins out to the west and south (Smith, 1970). It has not been recognized in southern Illinois. The shale is best known for the famous Mazon Creek sideritic concretions that are found in the Kankakee-Will-Grundy Counties area and have yielded what is probably the best known Pennsylvanian flora in the United States (Noé, 1925). In Will County and at one place in Fulton County, concretions in the shale have a diverse fauna (Johnson and Richardson, 1970). The upper part of the Francis Creek commonly contains a few sandstone beds, probably equivalent to the Jake Creek Sandstone.

**Jake Creek Sandstone Member**—The Jake Creek Sandstone Member of the Carbondale Formation (Wanless, 1957, p. 85, 89, 204) is named for Jake Creek in Fulton County, and the type section is along the upper part of the creek (NE 13, 4N-1E). The Jake Creek is recognized only in western Illinois, where it attains a maximum thickness of 18 feet along a north-south belt about 1 mile wide and appears to be on top

of the Francis Creek Shale. It may correlate with thin sandstones in the upper part of the Francis Creek Shale in other parts of the state.

**Mecca Quarry Shale Member**—The Mecca Quarry Shale Member of the Carbondale Formation (Zangerl and Richardson, 1963, p. 25) is named for Mecca, Parke County, Indiana, where the type section is in a small quarry that was excavated for study of the shale (SW NE 29, 15N-8W). The Mecca Quarry Shale is a hard, black fissile shale that locally is as much as 4 feet thick but more normally is 1-2 feet thick. It contains a varied marine fauna dominated by nektonic and planktonic forms. Large limestone concretions and small phosphatic lenses and nodules are common locally (fig. P-3C). The unit is very extensive in Illinois and adjacent states. It lies immediately above the Colchester (No. 2) Coal in much of southern and eastern Illinois and above the Francis Creek Shale in much of western and northern Illinois. Where the Francis Creek is more than about 30 feet thick, the Mecca Quarry is absent. The Mecca Quarry is generally overlain by the Oak Grove Limestone.

**Oak Grove Limestone Member**—The Oak Grove Limestone Member of the Carbondale Formation, originally called the Oak Grove beds (Wanless, 1931a, p. 184, 187, 192), is named for Oak Grove School in Fulton County, and the type section is in a ravine just north of the school (SW SE 6, 5N-3E) (Wanless, 1956, p. 10; 1957, p. 91, 197). In western and northern Illinois the Oak Grove consists of a remarkably persistent sequence of thin, lithologically and paleontologically distinctive limestone beds. Most of them are only a few inches thick, but some are a few feet thick. They are interbedded with dark gray and black shale beds that also have characteristic properties (Wanless, 1957, p. 91-94). The total thickness of the Oak Grove seldom exceeds 15 feet. Limestone units are less abundant in the Oak Grove in southern Illinois. The Lowell and Shawneetown Coals appear to occur within strata equivalent to the Oak Grove. Limestones equivalent to the Oak Grove are present in western Indiana, southern Iowa, and western Missouri.

**Lowell Coal Member**—The Lowell Coal Member of the Carbondale Formation (Willman and Payne, 1942, p. 102-105) is named for Lowell, La Salle County, where the coal is 10 inches thick in the type section, an exposure on the Vermilion River (SE SW 8, 32N-2E). It is a bright-banded, rather shaly coal underlain by a silty to sandy underclay and overlain by several feet of gray shale that contains two limestone beds, which are equivalent to upper units of the Oak Grove Limestone. The underclay overlies a siltstone containing plant root impressions, which in turn is underlain by gray shale containing additional limestone units equivalent to the Oak Grove Limestone. The Lowell Coal is present in northern Illinois and in the southern part of western Illinois. It is equivalent to the Shawneetown Coal in southwestern, southern, and eastern Illinois.

**Shawneetown Coal Member**—The Shawneetown Coal Member of the Carbondale Formation (Kosanke et al., 1960, p. 34-35) is named for Shawneetown, Gallatin County, where the type section is at a depth of 482.6 feet (erroneously given originally as 543.8 feet) in Union Colliery Company drill hole 28 (NW SW NW 23, 9S-9E) (Peppers, 1970, p. 43). It is the upper of two coals in southeastern Illinois lying between the Colchester (No. 2) and Summum (No. 4) Coals that had previously been called Coal 2A. The Shawneetown Coal is persistent in southern and eastern Illinois, but is known to crop out only in a strip mine near Mitchellsville, Saline County. It normally is thin, but in a few scattered drill holes it has been reported to be as much as 8 feet thick. It is overlain by dark shale and underlain by underclay. It is correlated with the Lowell Coal of northern and western Illinois and with the Survant Coal Member (IV) in eastern Indiana.

**Purington Shale Member**—The Purington Shale Member of the Carbondale Formation (Wanless, 1931a, p. 184, 188, 192) is named for the Purington Brick Company pit at East Galesburg, Knox County, which exposes the type section

(SW 17, 11N-2E) (Wanless, 1956, p. 10). The Purington is a widespread gray shale that overlies the Oak Grove Limestone and attains a maximum thickness of about 50 feet in western and northern Illinois. It commonly contains marine fossils and sideritic concretions in the bottom part and becomes silty and sandy toward the top.

**Pleasantview Sandstone Member**—The Pleasantview Sandstone Member of the Carbondale Formation (Wanless, 1929, p. 90) is named for Pleasantview (now Pleasant View), Schuyler County, and the type locality is along Mill Creek (31, 2N-1E) (Wanless, 1956, p. 10; 1957, p. 190). The sandstone occurs as sheet facies 20 feet or less thick and as channel facies as much as 80 feet thick. In the channel facies the sandstone cuts through underlying strata down to, and locally through, the Colchester (No. 2) Coal (Ekblaw, 1931; Rusnak, 1957). The sandstone is best developed in western Illinois, but a sandstone commonly present a short distance below the Summum (No. 4) Coal throughout the Illinois Basin is probably equivalent to the Pleasantview. It is generally overlain by several feet of shale, which separates it from the underclay of the Summum Coal.

**Kerton Creek Coal Member**—The Kerton Creek Coal Member of the Carbondale Formation (Ekblaw, 1931, p. 391) is named for Kerton Creek in Fulton County, along which the type section is exposed (NE NE 15, 3N-2E) (Wanless, 1956, p. 10; 1957, p. 98, 189). This coal is recognized only in Fulton County, where it occurs in channels that had been only partially filled with the underlying Pleasantview Sandstone. The coal is up to 5 feet thick and is either channeloid or quite high in ash. The Summum (No. 4) Coal, which also thickens in the same unfilled channels, overlies the Kerton Creek by only a few feet. The Kerton Creek does not have an underclay but rests directly on the Pleasantview Sandstone. It is believed to correlate with the Roodhouse Coal of Greene County.

**Roodhouse Coal Member**—The Roodhouse Coal Member of the Carbondale Formation (Siever, in Wanless, 1956, correlation chart, pl. 1) is named for Roodhouse, Greene County, near the type section (NW 21, 12N-11W) (Kosanke et al., 1960, p. 35, 47). The coal is channeloid and, like the Kerton Creek Coal of southern Fulton County, occurs immediately above a channel facies of the Pleasantview Sandstone, apparently in channels that were not completely filled by the sandstone (Wanless, 1957, p. 98). The coal is as much as 5 feet thick near the center of the channels but is not present outside them. It directly overlies the Pleasantview Sandstone, without an underclay. It probably correlates with the Kerton Creek Coal in Fulton County.

**Breezy Hill Limestone Member**—The Breezy Hill Limestone Member of the Carbondale Formation (Pierce and Courtier, 1937, p. 17) is named for Breezy Hill, Crawford County, Kansas, where the type section is exposed. The Breezy Hill Limestone occurs in the lower part of the underclay of the Summum (No. 4) Coal in western and northern Illinois (Inden, 1968; Nance, 1970). The member is widespread, though sporadic. It occurs either as an irregular, silty limestone, rarely over 1 foot thick, or as nodular masses in claystone. The only fossils found in it in western Illinois are micritic patches and filaments, probably algal. This limestone is interpreted as fresh-water in Illinois and open-marine to the west in Kansas and Oklahoma, where it is several feet thick and contains a varied marine fauna. In Missouri it occurs at the base of the underclay of the Mulky coal (Inden, 1968; Nance, 1970).

**Summum (No. 4) Coal Member**—The Summum (No. 4) Coal Member of the Carbondale Formation (Wanless, 1931a, p. 182, 192) is named for Summum, Fulton County, near the type locality (NE 3, 3N-2E) (Wanless, 1956, p. 10; 1957, p. 204). The term "No. 4" was first used by Lesquereaux (1866, p. 213) for this coal near Shawneetown, Gallatin County. It was also applied incorrectly by Worthen (1870) to the Springfield (No. 5) Coal in parts of Fulton County. The coal, or the recognized position of the coal, is one of the

most widespread stratigraphic markers in the state, but it is generally thin and has been mined only locally in Grundy, Kankakee, Fulton, and Saline Counties. It normally is overlain by the black Excello Shale and overlies an underclay. It is correlated with the Mulky coal of Missouri and Kansas, the Houchin Creek Coal Member (IVA) in Indiana, and the No. 8b coal in western Kentucky.

**Excello Shale Member**—The Excello Shale Member of the Carbondale Formation (Searight et al., 1953) is named for Excello, Macon County, Missouri. In Illinois, the Excello is composed of black fissile shale that is generally 1-3 feet thick and similar in character to the member in Missouri (Nance, 1970, p. 77). Large black limestone concretions commonly occur in the lower part. It generally directly underlies the Hanover Limestone, but in some places in western Illinois a lighter colored shale a few feet thick intervenes. The Excello immediately overlies the Summum (No. 4) Coal, except locally in northern Illinois where a few feet of gray shale separates them.

**Hanover Limestone Member**—The Hanover Limestone Member of the Carbondale Formation (Wanless, in Lamar et al., 1934, p. 84; 1957, p. 101) is named for Hanover School, Greene County, near the type locality (NE SW 27, 10N-11W) (Wanless, 1956, p. 10; 1957, p. 101). The Hanover is a thin marine limestone that is seldom more than 4 feet thick and in places is represented only by nodules of limestone or a thin concentration of marine fossils in which brachiopods are dominant. It is a persistent bed of gray, argillaceous, brecciated or nodular limestone in most of western and northern Illinois, where it overlies the black Excello Shale. It is poorly developed in southern Illinois. The Hanover is one of the most widespread Pennsylvanian limestones in the central United States and is equivalent to the Blackjack Creek Limestone of Kansas, Oklahoma, and Missouri (Wanless, 1957, p. 101).

**Covel Conglomerate Member**—The Covel Conglomerate Member of the Carbondale Formation (Willman, 1939, p. 174-176) is named for Covel Creek in La Salle County, and the type section is along the creek near its mouth (SE SW 26, 33N-3E) (Willman and Payne, 1942, p. 116; Wanless, 1956, p. 10). This unit is remarkably persistent in northern Illinois and is locally present in western and eastern Illinois. It is composed of rounded, dark gray to black, phosphatic limestone pebbles and water-worn marine fossils in a matrix of lighter gray limestone or of pyrite. In many places the member is covered with laminated algal growths. The Covel is generally 1-3 inches thick and is an easily recognized stratigraphic marker. It is also present in southern Iowa and western Indiana (Wanless, 1957).

**Springfield and Harrisburg (No. 5) Coal Members**—The Springfield (No. 5) Coal Member and the Harrisburg (No. 5) Coal Member of the Carbondale Formation are the same unit, but separate names are retained because of long-established usage—"Springfield" in central, northern, and western Illinois and "Harrisburg" in southern and eastern Illinois. The term "No. 5" was first applied to this coal by Worthen (1870, p. 93) in his description of the geology of Fulton County. It was later applied to the coal mined in the Springfield, Sangamon County, district (Shaw and Savage, 1913, p. 3), and underground exposures in coal mines were made the type section (16, 16N-4W) (Wanless, 1956, p. 10). The Harrisburg (No. 5) Coal Member (Shaw and Savage, 1912, p. 7) is named for Harrisburg, Saline County, where it is mined. The No. 5 Coal is second only to the Herrin (No. 6) Coal in commercial importance in Illinois. It is commonly 4-8 feet thick (fig. P-12). In southwestern Illinois it has been strip mined in a few pits where the Herrin is the principal coal. The coal is absent along the northern margin of the Pennsylvanian rocks. It is normally overlain by a black fissile shale, but in southeastern Illinois, in a belt several miles wide that trends southwestward, the coal is thick and it is overlain by the gray silty Dykersburg Shale. In that belt the coal is more commonly split by shale partings, and contains less pyrite than where it is overlain by the black fissile shale (Hopkins,

1968). The No. 5 Coal is the most important coal in Indiana, where it is now called the Springfield Coal Member (V), and in western Kentucky, where it is called the No. 9 (Mulford) coal. It is correlated with the Summit coal in Missouri.

**Dykersburg Shale Member**—The Dykersburg Shale Member of the Carbondale Formation (Hopkins, 1968, p. 4) is named for Dykersburg (called Absher on some maps), Williamson County, near which the type section is in the high wall of an abandoned coal strip pit (SE SE NE 34, 9S-4E). The Dykersburg is confined to a belt 3-15 miles wide that extends southwestward from Wabash County to the outcrop in Saline County. Most of it is gray silty shale containing some sandstone, particularly one major channel sandstone that replaces the Harrisburg Coal along a narrow band. The Dykersburg is as much as 100 feet thick in places. Where overlain by the Dykersburg Shale, the Harrisburg Coal is thicker, is commonly characterized by several shale splits, and contains much less sulfur (less pyrite) than in areas where it is overlain by black fissile shale or the St. David Limestone. The Dykersburg is also well developed in an adjacent area in western Indiana.

**St. David Limestone Member**—The St. David Limestone Member of the Carbondale Formation (Savage, 1927, p. 309) is named for St. David, Fulton County, and the type section consists of outcrops near the village (SE SE 17, 6N-4E) (Wanless, 1956, p. 10; 1957, p. 105, 197). The St. David is a thin, dark gray, argillaceous limestone containing an abundant open-marine fauna dominated by brachiopods; it also contains a few fusulinids. It is almost invariably present where the Springfield-Harrisburg (No. 5) Coal occurs, although the limestone and coal are generally separated by 1-3 feet of black fissile shale. The St. David is widespread in western Illinois, where its thickness is generally less than 1 foot but locally reaches 2 feet. In eastern and southwestern Illinois also it is persistent and locally is 3-4 feet thick. In southeastern Illinois and western Kentucky, it is continuous but is commonly no more than a few inches of very fossiliferous calcareous shale or impure limestone. The underlying black fissile shale is widely characterized by an abundance of *Dunbarella rectilaterarius* (fig. P-6) in its lower few inches. The St. David is usually absent where the gray Dykersburg Shale, which underlies it in places, is more than 25 or 30 feet thick.

**Canton Shale Member**—The Canton Shale Member of the Carbondale Formation (Savage, 1921a, p. 240-241) is named for Canton, Fulton County, and the type section consists of outcrops along Big Creek (cen. 9, 6N-4E). The Canton is a gray, rather uniform shale that tends to be decidedly silty in its upper part. In western and northern Illinois, where it is primarily recognized and is as much as 50 feet thick, the lower few feet is dark gray and contains a varied marine fauna and several layers of fossiliferous, calcareous concretions. In northern Illinois a 4-6 inch bed of canneloid coal occurs locally about 10 feet above the base of the Canton. In central and western Illinois, from south of Springfield to the vicinity of Du Quoin in Perry County, the interval between the Herrin (No. 6) and Springfield-Harrisburg (No. 5) Coals thins, and the Canton Shale is only a foot or so thick or is absent. In southern Illinois the shale above the St. David Limestone and the shale either immediately or a few feet above the Briar Hill Coal may be in part equivalent to the Canton.

**Briar Hill (No. 5A) Coal Member**—The Briar Hill (No. 5A) Coal Member of the Carbondale Formation (Glenn, 1912, p. 38) is named for Briar Hill, a hill near Dekoven Station, Union County, Kentucky. The name was adopted in Illinois (Cady, 1919a, p. 20; 1926, p. 255), and a locality in Saline County (9S-7E) was designated as representative for Illinois (Wanless, 1956, p. 10). In Kentucky, this coal is now referred to as the No. 10 coal. In Illinois, the Briar Hill is fairly continuous in southeastern Illinois and has been recognized as far as Clark County on the northeast and Mt. Vernon on the northwest. It is generally thin and has been mined only on a small scale in the state. The coal is overlain by a dark

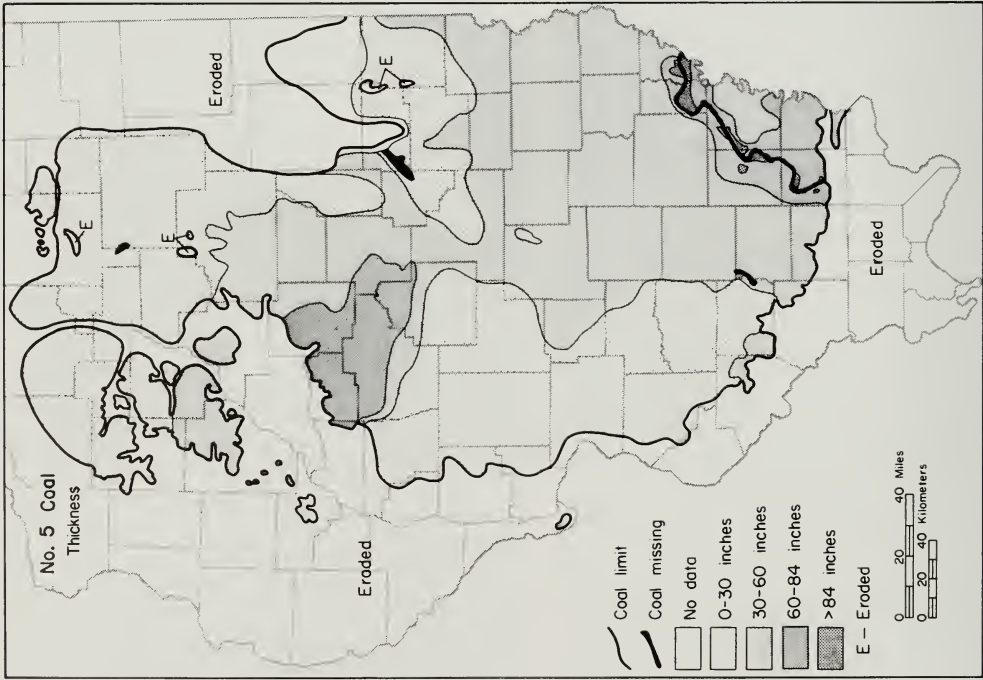


Fig. P-12—Thickness of the Harrisburg (No. 5) and Springfield (No. 6) Coal Members (based on map by K. E. Clegg).

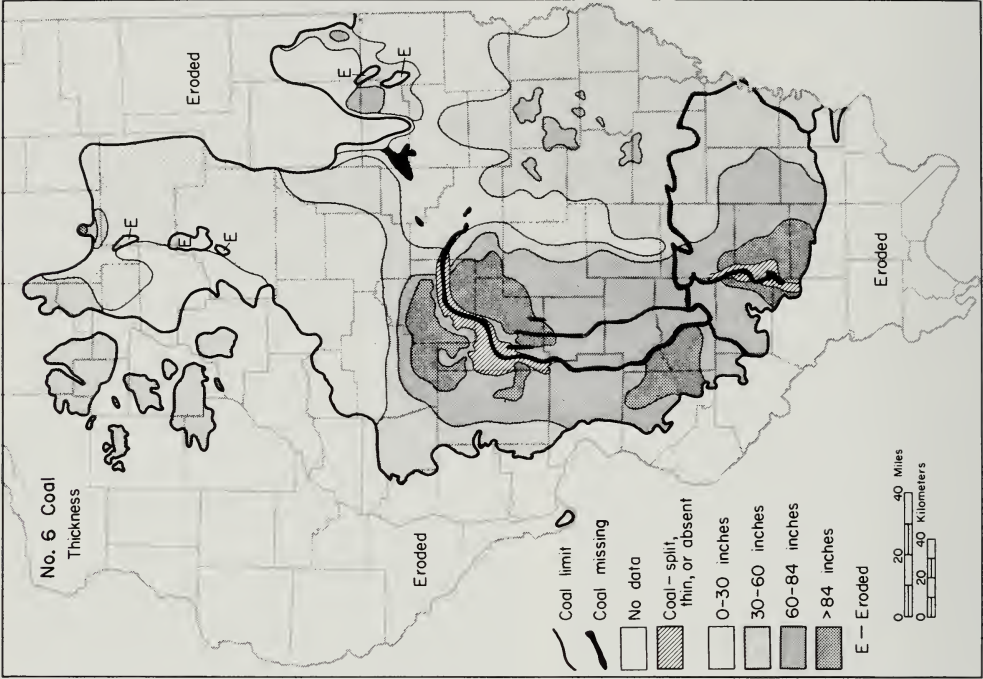


Fig. P-13—Thickness of the Herrin (No. 6) Coal Member (based on map by K. E. Clegg).

gray to black shale that is fissile in places and is seldom over 2 feet thick. It is underlain by a hard silty underclay. It extends into southwestern Indiana.

**Vermilionville Sandstone Member**—The Vermilionville Sandstone Member of the Carbondale Formation (Cady, 1915, p. 29) is named for Vermilionville, La Salle County, and the type locality is west of the village, along the Vermilion River (SE 9, 32N-2E) (Wanless, 1956, p. 10). The Vermilionville is an argillaceous to silty, fine-grained sandstone that in places occupies channels cut into the underlying strata. In such channels it is as much as 80 feet thick. It is well developed in northern and western Illinois, where it occurs in the interval between the Herrin (No. 6) and the Springfield (No. 5) Coals. It is probably present in southern Illinois, where three sandstone units, all of which locally occur in channels, are present in this interval. One sandstone is below the Herrin Coal, another is below the Briar Hill (No. 5A) Coal, and a third is associated with the Dykersburg Shale. The Vermilionville is generally overlain by a few feet of the Big Creek Shale and is underlain by the Canton Shale. The Vermilionville was formerly called Cuba Sandstone in western Illinois (Savage, 1927) and Waupecan Sandstone in north-eastern Illinois (Culver, 1922a).

**Big Creek Shale Member**—The Big Creek Shale Member of the Carbondale Formation (Savage, 1927, p. 309, 313, 315) is named for Big Creek in Fulton County, along which the type section occurs (7N-4E) (Wanless, 1957, p. 108). The shale is gray, soft, and sandy, is 10-30 feet thick, and grades into the underlying Vermilionville Sandstone. A shale is present at this position throughout much of the state, but the name has been used only in western Illinois.

**Spring Lake Coal Member**—The Spring Lake Coal Member of the Carbondale Formation (Cady, 1948, p. 5; Peppers, 1970, p. 59) is named for Spring Lake, La Salle County. The type section consists of exposures on the east bank of the Vermilion River on the northwest side of Streator, about three-fourths of a mile northeast of the lake (SE SW SW 23, 31N-3E) (Willman and Payne, 1942, p. 130, 295; Peppers, 1970, p. 59). The coal was described from several outcrops and mines in a small area near Streator, where it has a maximum thickness of 2.5 feet (Willman and Payne, 1942, Unit 43). It is separated from the overlying Herrin (No. 6) Coal by 11-17 feet of strata, the lower part of which consists of black fissile shale and gray shale. *Estheria* and *Leaia* are found in the gray shale. Spore analyses by Peppers (1970) suggest that its position is slightly above the Briar Hill Coal.

**Herrin (No. 6) Coal Member**—The Herrin (No. 6) Coal Member of the Carbondale Formation was originally named No. 6 Coal (Worthen, 1870, p. 93) and later called Herrin (No. 6) Coal (Shaw and Savage, 1912, p. 6) for Herrin, Williamson County, where the coal is extensively mined. It formerly was called the Brereton (No. 6) coal in western Illinois, the "Second Vein" (No. 5) coal in the La Salle area, and the Streator (No. 7) coal in the Streator area. The coal is a normal bright-banded coal. Its lower portion contains a prominent claystone parting (the "blue band") that normally is 1-3 inches thick. The Herrin Coal is present throughout much of the area of Pennsylvanian rocks (fig. P-13). It averages more than 6 feet thick in extensive areas and locally reaches 15 feet. It is thin in much of central Illinois but has been extensively mined in western, west-central, southern, and northern Illinois, as well as in the southern part of the Danville region of eastern Illinois. In some places the coal is cut out by channels filled with the Anvil Rock Sandstone Member. In parts of Illinois, silty gray shale as much as 100 feet thick overlies the Herrin Coal. Associated with this shale is a channel sandstone commonly as much as a mile wide and 60-80 feet thick that was mapped as Anvil Rock Sandstone (Hopkins, 1958; Potter and Simon, 1961), but later unpublished studies suggest that it may be in part contemporaneous

with the coal. In areas where the coal is overlain by relatively thick bodies of the gray shale, the coal generally varies in thickness, locally contains gray shale lenses up to a few tens of feet thick, and has a much lower sulfur content than it does elsewhere (Gluskoter and Simon, 1968; Gluskoter and Hopkins, 1970). The gray shale overlies the coal in four areas, principally in parts of the following counties: (1) Williamson, Franklin, and Jefferson, (2) Madison and St. Clair, (3) eastern Macoupin, and (4) southern Vermilion. Except in these areas the Herrin Coal is generally overlain by either the Anna Shale Member (black fissile shale) or the Brereton Limestone Member. The Herrin Coal rests on a well developed underclay. The coal extends into western Indiana, where it is now called the Herrin Coal Member. It is extensively mined in western Kentucky, where it is known as the No. 11 coal, and it is correlated with the Lexington coal in Missouri and the Mystic Coal Member in Iowa.

**Anna Shale Member**—The Anna Shale Member of the Carbondale Formation (Jewett, 1941, p. 316-317) is named for Anna, Bourbon County, Kansas. It is a fissile, black, hard, carbonaceous shale that seldom is as much as 4 feet thick. Locally it contains dark gray, impure limestone concretions up to a foot thick. The Anna has a nektonic and planktonic marine fauna and many of the shells are fragmentary and pyritized. The Anna is persistent and generally accompanies the overlying Brereton Limestone, but in parts of southern Illinois the Anna lenses out and the Brereton Limestone lies directly on the Herrin (No. 6) Coal. The Anna otherwise generally lies in abrupt contact with the Herrin Coal, except where the thick wedges of silty gray shale intervene. The Anna Shale and the Brereton Limestone, and locally even higher units, thin to zero over the gray shale wedges.

**Brereton Limestone Member**—The Brereton Limestone Member of the Carbondale Formation (Savage, 1927, p. 309, 313-315) is named for Brereton, Fulton County, and the type section is along the east bank of Middle Copperas Creek (SE NE 1, 7N-4E) (Wanless, 1956, p. 10; 1957, p. 107, 111, 112, 195). It was formerly called the Herrin Limestone in southern Illinois. The Brereton Limestone is a distinctive marker unit widely developed throughout much of the Illinois Basin (fig. P-3B). It is usually dark gray, argillaceous, fine grained, and commonly less than 5 feet thick, but in places it is as thick as 18 feet. In northern Illinois it contains black phosphatic nodules. It has an open-marine fauna dominated by brachiopods, crinoids, and fusulinids. It is absent in areas where cut by channels in which the Anvil Rock Sandstone was deposited. It thins and disappears over thick deposits of the silty gray shale that locally overlies the Herrin (No. 6) Coal. In parts of southwestern, western, and eastern Illinois, the Brereton Limestone or the Anna Shale are lenticular and pinch out in places. Where both are absent, the overlying Lawson Shale or strata associated with the Jamestown Coal locally form the roof of the Herrin Coal. In southern and parts of west-central Illinois the Brereton is commonly overlain by a few inches to a few feet of the dark gray calcareous shale that underlies the Jamestown Coal. In the rest of the state the limestone is overlain by the Lawson Shale. The Brereton Limestone is present in southwestern Indiana and is quite persistent in western Kentucky, where it is called the Providence Limestone Member. It is correlated with the Myrick Station Member of Missouri.

**Jamestown Coal Member**—The Jamestown Coal Member of the Carbondale Formation (Bell et al., 1931, p. 3) is a widespread but thin coal in southern Illinois named for Jamestown, Perry County, which is near the type locality (NW NE 34, 5S-4W) (Wanless, 1939, p. 17, 19, 88; 1956, p. 10). The coal is seldom more than a few inches thick in southern Illinois (fig. P-3B), but in southern Clark County and adjacent Crawford County in eastern Illinois it is reported in drill records to be as much as 6 feet thick. The Jamestown Coal is equivalent to the Hymera Coal Member (V1), which is an im-

portant commercial coal in Indiana, and to the No. 12 coal in western Kentucky.

**Conant Limestone Member**—The Conant Limestone Member of the Carbondale Formation (Kosanke et al., 1960, p. 35) is named for Conant, Perry County, near the type locality (NW NE 34, 5S-4W) (Wanless, 1939, p. 17, 88; 1956, p. 10). It previously was called the Jamestown Limestone (Bell et al., 1931, p. 3). The Conant is widespread from St. Clair to Gallatin Counties in southern Illinois (fig. P-3B) but is not recognized a short distance north of that area. It is also present locally in eastern Illinois. For most of its extent the limestone is less than 1 foot thick and lies immediately above the thin Jamestown Coal, but in Perry County it is as much as 4 feet thick in places and is separated from the Jamestown Coal by an equal thickness of dark gray shale. It is overlain by gray silty shale. The limestone is quite argillaceous and locally resembles the Brereton Limestone. It is characterized by an open-marine fauna dominated by the large productid brachiopod *Dictyoclostus*.

**Pokeberry Limestone Member**—The Pokeberry Limestone Member of the Carbondale Formation (Wanless, 1939, p. 17, 98) is named for Pokeberry School, Schuyler County, which is near the type locality (NW 26, 2N-1W) (Wanless, 1956, p. 11; 1957, p. 113, 188). The limestone is known only in the type area, where it is 15 feet above the Herrin Coal and 9 feet below the Danville (No. 7) Coal. It is a gray, dense, locally conglomeratic or brecciated limestone containing large fossils, most of them brachiopods. It has a very knobby upper surface. It was correlated by Wanless (1957, p. 113) with the Conant Limestone, but its position and correlation are uncertain. It may correlate with the Bankston Fork Limestone. The Pokeberry Limestone is not shown on the geologic column (fig. P-2).

**Lawson Shale Member**—The Lawson Shale Member of the Carbondale Formation (Kosanke et al., 1960, p. 35) is named for Lawson Creek in Bureau County, about a mile west of the type section (cen. 24, 16N-6E) (Wanless, 1956, p. 10; 1957, p. 112). It previously was called Sheffield Shale (Wanless, 1939, p. 102; 1956, p. 10; 1957, p. 112). The Lawson is typically a gray silty shale as much as 25 feet thick in western Illinois. It probably correlates with a similar shale that underlies the Anvil Rock Sandstone in southern Illinois. The upper part of the Lawson is in some places interbedded with sandstone that grades laterally into the Copperas Creek Sandstone. At other places the Copperas Creek lies unconformably on the shale. In much of west-central and southwestern Illinois the Lawson is a weak, gray and green mottled shale. It is underlain throughout most of western Illinois by the Brereton Limestone or, locally, by either the Anna Shale or Herrin (No. 6) Coal.

**Copperas Creek Sandstone Member**—The Copperas Creek Sandstone Member of the Carbondale Formation (Savage, 1927, p. 309) is named for Copperas Creek in Fulton County, along which the sandstone is well exposed (Wanless, 1957, p. 114), but no type section was designated. The Copperas Creek occurs in western Illinois as a widespread, thin-bedded sheet sandstone and as a channel sandstone. It is correlated with the Anvil Rock Sandstone of southern Illinois. The Copperas Creek channels appear to be part of a south-to-southeast drainage system that connects with the Anvil Rock Sandstone channels of the deeper part of the Illinois Basin.

**Anvil Rock Sandstone Member**—The Anvil Rock Sandstone Member of the Carbondale Formation (Owen, 1856, p. 45) is named for an anvil-shaped float block along a bluff 1.5 miles north of Dekoven Station, Union County, Kentucky. The sandstone underlies the Bankston Fork Limestone and overlies the gray shale above the Conant Limestone throughout southern Illinois, where it occurs as a channel sandstone as much as 80 feet thick. The name "Anvil Rock" was applied by Hopkins (1958) and Potter and Simon (1961) to a major channel sandstone, which replaces the Herrin Coal along a sinuous band extending through Montgomery, Bond, Clinton, Washington, Jefferson, and Franklin Counties (fig.

P-13), which is now considered to be in part contemporaneous with the Herrin Coal and the immediately overlying gray silty shale. East of the Du Quoin Monocline the Anvil Rock occurs as a channel sandstone or, more commonly, as a sheet sandstone up to 20 feet thick (Hopkins, 1958; Potter and Simon, 1961). In the sheet facies it is normally a fine-grained, relatively impure, quartz sandstone incorporating considerable argillaceous material, but in the channel facies it is medium grained and less argillaceous. In the deeper channels the sandstone cuts through several underlying stratigraphic units, including the Herrin (No. 6) Coal. Some channels are only a few hundred feet across, but the major ones are up to 2 miles wide. In the sheet facies the dominant sedimentary structure is ripple bedding. In the channel facies, planar and trough cross-bedding are common.

**Bankston Fork Limestone Member**—The Bankston Fork Limestone Member of the Carbondale Formation (Cady, 1926, p. 261-262) is named for Bankston Creek in Saline County, where the type section consists of outcrops along the south side of the creek (NE NW 19, 9S-5E). The Bankston Fork is a fine-grained, argillaceous, thick-bedded limestone that is dolomitic in places (fig. P-3B). It is commonly nodular in the upper and lower portions and is generally divided into two benches by a greenish gray shale several inches thick. It is sparsely fossiliferous, its open-marine fauna dominated by brachiopods, fusulinids, and a few crinoids. It occurs in southwestern, central, eastern, and southeastern Illinois, where it is commonly several feet thick but seldom over 6 feet. It does not occur west of the Illinois River or in northern Illinois. It commonly is not present over the thick portions of the Anvil Rock Sandstone. The Bankston Fork correlates with the Universal Limestone Member of Indiana and is present in parts of western Kentucky, where it locally is as much as 8 feet thick.

**Allenby Coal Member**—The Allenby Coal Member of the Carbondale Formation (Kosanke et al., 1960, p. 35, 48) is named for Allenby, Saline County, and the type locality is in Williamson County, half a mile northeast of the village along the roadside east of a railroad crossing (NE NW 24, 9S-4E) (Kosanke, 1950, p. 79), where it occurs 1-2 feet above the Bankston Fork Limestone. It was formerly called the Bankston Coal (Wanless, 1939, p. 14, 76). It is a thin coaly zone occurring in much of Williamson, Saline, and Gallatin Counties. It is generally overlain by a greenish gray or gray shale and is underlain by underclay. It is minable locally in western Kentucky, where it is called the Baker coal.

**Galum Limestone Member**—The Galum Limestone Member of the Carbondale Formation (Bell et al., 1931, p. 3) is named for Galum Creek, Perry County, along which the type section occurs (near cen. N line 13, 6S-4W) (Wanless, 1956, p. 11). It is recognized only in and near Perry County. It is generally an impure, argillaceous, nodular, nonfossiliferous limestone that is seldom more than 3 feet thick. It is overlain by the underclay of the Danville (No. 7) Coal and underlain by a few feet of greenish gray shale that separates the Galum from the Bankston Fork Limestone.

**Danville (No. 7) Coal Member**—The Danville (No. 7) Coal Member of the Carbondale Formation (Bradley, 1870, p. 250-252), the uppermost member of the formation, is named for Danville, Vermilion County, near the type section (E1/2 7, 19N-11W) (Wanless, 1956, p. 11), where it is an important commercial coal that has been mined since the latter part of the 1800s. In the type locality it is 6 feet thick and occurs 20 feet above the Herrin (No. 6) Coal. It previously was called the Sparland (No. 7) coal in western Illinois and the "First Vein" (No. 7) coal in northern Illinois. The Danville Coal is extensive and has been mined in Livingston, McLean, La Salle, and Marshall Counties in addition to Vermilion County. In most of the remainder of the state it is a thin coal, generally from a few inches to less than 3 feet thick. The position of the coal is easily recognized in the subsurface in both lithologic and geophysical logs. The No. 7 Coal is generally overlain by the Farmington Shale Member

of the Modesto Formation, but in places the immediate roof is 1-2 feet of black fissile shale. It is underlain by a relatively thick underclay, which has been mined in La Salle and Marshall Counties as ceramic clay. The Danville Coal correlates with the Danville Coal Member (VII) of Indiana and is present as a thin coal in western Kentucky.

## McLeansboro Group

The McLeansboro Group (DeWolf, 1910, p. 181; Weller, 1940, p. 36) is named for McLeansboro, Hamilton County, and the type section consists of strata in a diamond drill core from a boring near McLeansboro (SE SW SW NE 25, 4S-5E), where 811 feet of Pennsylvanian strata was encountered above the top of the Danville (No. 7) Coal, which defines the base of the group. The McLeansboro includes all Pennsylvanian rocks in Illinois above the No. 7 Coal and is made up of three formations—the Modesto, Bond, and Mattoon (fig. P-2). DeWolf originally applied formation status to the McLeansboro, but Weller (1940) elevated it to a group and Willman and Payne (1942) defined it as including all the Pennsylvanian strata in Illinois above the base of the Copperas Creek (Anvil Rock) Sandstone Member. About 400 feet of additional Pennsylvanian strata younger than those encountered in the type section drill hole are present in the deeper part of the Illinois Basin in Jasper County, and even younger Pennsylvanian rocks are present in western Kentucky. Lithologically the McLeansboro is similar to the Kewanee Group, but it contains more marine members, including thicker, less argillaceous limestones. Coals are not as thick and probably not as extensive in the McLeansboro. Most are less than 1 foot thick, although some coals are up to 4 feet thick. Variegated claystones, many of them dominantly red, occur several feet above and below some of the limestones. They are much less common in other Pennsylvanian groups. Light olive or tan argillaceous limestone units up to 3-4 feet thick and bearing only ostracodes, *Spirorbis*, and very few pelecypods are present in the McLeansboro, particularly in the upper part. They are similar to thicker limestones in the upper part of the Pennsylvanian in the Appalachian Basin. The Dix Limestone is the only one of these units that has been named. The McLeansboro Group extends into Indiana, and is equivalent to all but the lowest part of the Sturgis Formation of Kentucky.

## Modesto Formation

The Modesto Formation of the McLeansboro Group (Kosanke et al., 1960, p. 36, 48, 67-70) is named for

Modesto, Macoupin County, near which four outcrops described by Payne (1942) and Ball (1952) constitute the type locality and expose nearly all the formation (SW SE 35, 10N-7W and NE NW 2, 9N-7W; W1/2 NE NW 35, 10N-7W; SW SW SE 7, 12N-8W to NE SE SW 1, 12N-9W; and NE SW SW 16 to NE 17, 12N-9W). The Modesto Formation includes strata from the top of the Danville (No. 7) Coal to the base of the Shoal Creek Limestone Member or the La Salle Limestone Member (fig. P-2). It is overlain by the Bond Formation and underlain by the Carbondale Formation. The Modesto Formation thickens from less than 125 feet along the La Salle Anticlinal Belt in east-central Illinois to over 200 feet in northern Illinois and over 450 feet in southern Illinois, averaging about 350 feet (fig. P-14). It consists of sediments somewhat similar to those of the underlying Carbondale Formation, but the coals are thinner, the limestones are generally thicker and less argillaceous, and several red claystones and shales are associated with the open-marine limestones. With the exception of the Lonsdale, Piasa, and West Franklin Limestones, most of the limestones of this formation, however, are thin and argillaceous. Even though the coals are thin, many are widespread. The sandstones in places are thick channel deposits up to 80 feet thick. Gray shales in this formation are particularly thick and constitute by far the greater part of the formation. The Modesto Formation correlates with the Shelburn Formation and the overlying Patoka Formation of Indiana and a portion of the Sturgis Formation of western Kentucky.

**Farmington Shale Member**—The Farmington Shale Member of the Modesto Formation (Savage, 1927, p. 309) is named for Farmington Township, Fulton County, which is the type locality (8N-4E) (Wanless, 1956, p. 11). The Farmington is the lowest named unit of the Modesto Formation in most of the state. It is commonly gray shale that becomes coarser grained upward, and the lower part generally contains marine fossils. It generally occurs immediately above the Danville (No. 7) Coal Member, but in several places a dark gray, very impure limestone, usually less than a foot thick, lies directly on the coal. In other places black fissile shale, seldom more than 2 feet thick, overlies the coal or occurs between the limestone and the Farmington Shale. The Farmington ranges from a few feet to as much as 50 feet thick in eastern, western, and southern Illinois and to as much as 100 feet or more in southeastern Illinois. It has been extensively mined for clay in the Danville region, Vermilion County.

**Piasa Limestone Member**—The Piasa Limestone Member of the Modesto Formation (Culver, 1925, p. 20) is named for Piasa Creek in Jersey County and the type section consists of exposures along the creek (E1/2 25, 8N-10W) (Wanless, 1956, p. 11). The Piasa, which occurs in southwestern and southern Illinois, was formerly called the Cutler Limestone in southern Illinois. In much of southwestern Illinois the Piasa lies only a few feet above the Danville (No. 7) Coal and is separated from it by either variegated claystone, gray shale, or, in places, black fissile shale. The Piasa is commonly light gray, fine-grained, argillaceous limestone containing an open-marine fauna dominated by crinoids (mainly in the lower part) and brachiopods. In many places it contains numerous fusulinids, especially at the base. It is generally less than 4 feet thick and is commonly associated with red and variegated claystone. Correlations with other units in Illinois are not definite, but the Piasa appears to be equivalent to the lower part of the West Franklin Limestone Member of southeastern Illinois and southwestern Indiana and to the Madisonville Limestone Member of western Kentucky.

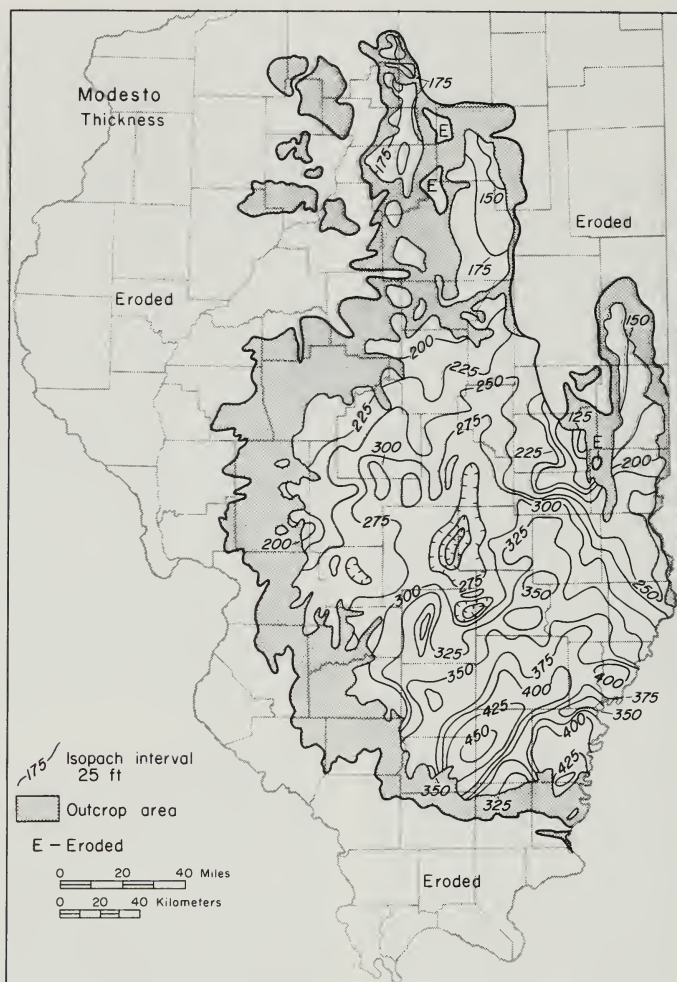


Fig. P-14—Thickness of the Modesto Formation (based on map by K. E. Clegg).

**West Franklin Limestone Member**—The West Franklin Limestone Member of the Modesto Formation (Collett, 1884, p. 61-62) is named for West Franklin, Posey County, Indiana. The type section consists of outcrops near the town (24, 7S-12W) (Wanless, 1956, p. 11). The member is recognized largely in southeastern Illinois. It is a fine-grained limestone generally less than 15 feet thick and occurs in one to three benches, each generally less than 10 feet thick and separated by a few feet of greenish gray to variegated claystone. The number of limestone benches decreases to the west as the underlying shale, probably the Farmington Shale, thins from east to west. In the eastern part of its area the West Franklin is closely overlain by the Chapel (No. 8) Coal, and it is likely that the West Franklin Limestone is equivalent to the entire interval from the Piasa Limestone upward through the Lake Creek Coal in southern Illinois and through the Scottville Limestone in southwestern Illinois. The Piasa Limestone also may be equivalent to the lower bench of the West Franklin (Andresen, 1956). The West Franklin is probably also equivalent to the interval including the Lonsdale and Exline Lime-

stones of western Illinois and to the Madisonville Limestone of western Kentucky.

**De Graff Coal Member**—The De Graff Coal Member of the Modesto Formation (Cady, in Kosanke et al., 1960, p. 37) is named for De Graff School, Perry County. It previously was informally called the First Cutler Rider coal. The type section consists of exposures along Galum Creek, near De Graff School (SE cor. NE SW 21, 5S-4W). This thin, lenticular coal occurs a few feet above the Piasa Limestone in southern Illinois.

**Rock Branch Coal Member**—The Rock Branch Coal Member of the Modesto Formation (Kosanke et al., 1960, p. 37) is named for Rock Branch in Macoupin County. It previously was called the Scottville Coal (Payne, 1942, p. 4). The type section consists of exposures along Rock Branch (SW SW NW 16, 12N-9W). This thin coal occurs in southwestern Illinois and may be equivalent to the Pond Creek Coal of southern Illinois.

**Gimlet Sandstone Member**—The Gimlet Sandstone Member of the Modesto Formation (Wanless, 1931a, p. 182, 183, 190, 192) is named for Gimlet Creek in Marshall County, and the type section consists of exposures along the creek (N1/2 SE 16, 12N-9E) (Wanless, 1956, p. 11; 1957, p. 116). The Gimlet Sandstone is locally developed as a fine- to medium-grained channel sandstone 50-60 feet thick, which cuts down from 50 feet above the Danville Coal to within a few feet of the Brereton Limestone. In other places the sandstone is only a few feet thick or is absent. The Gimlet Sandstone has been recognized principally in northern and western Illinois.

**Lonsdale Limestone Member**—The Lonsdale Limestone Member of the Modesto Formation (Worthen, 1873, p. 328) is named for the old Lonsdale quarries, Peoria County. The original type section in the old quarry (N1/2 6, 8N-7E) is no longer accessible, and an outcrop near by (14, 8N-7E) is a supplementary type section (Wanless, 1957, p. 194). The Lonsdale is a well developed limestone in western and northern Illinois, where it averages 6-8 feet thick and locally is as much as 25 feet thick. It is a very fine-grained, light gray limestone, conglomeratic in part. Throughout much of its area of occurrence the upper part is nodular. It contains a large and diversified marine fauna locally rich in fusulinids. It is correlative with at least a part of the West Franklin Limestone of southeastern Illinois, the Cooper Creek Limestone of Iowa, and the Madisonville Limestone Member of western Kentucky.

**Pond Creek Coal Member**—The Pond Creek Coal Member (Kosanke et al., 1960, p. 37) is named for Pond Creek in Williamson County. It previously was informally called the Second Cutler Rider coal. The type section of the Pond Creek Coal is at a depth of 125 feet in Consolidated Coal Company drill hole 91 (SW NE NE 21, 8S-3E). The Pond Creek is more extensive than either the De Graff Coal or the Lake Creek Coal, which, respectively, lie just a few feet above and below the Pond Creek, but the Pond Creek is recognized only in southern Illinois. It may be equivalent to the Rock Branch Coal of southwestern Illinois.

**Lake Creek Coal Member**—The Lake Creek Coal Member of the Modesto Formation is named for Lake Creek Township, Williamson County (Cady, in Kosanke et al., 1960, p. 37). It previously was informally called the Third Cutler Rider coal. The type section of the Lake Creek Coal is at a depth of 86.6 feet in the Consolidated Coal Company drill hole 91 (SW NE NE 21, 8S-3E), located in Lake Creek Township. The coal is lenticular and occurs in southern Illinois.

**Athensville Coal Member**—The Athensville Coal Member of the Modesto Formation (Kosanke et al., 1960, p. 37) is named for Athensville, Greene County. It previously was called Upper Scottville (Kosanke, 1950, p. 85). The type section consists of exposures near the town (SE NW SW 16, 12N-9W, Macoupin County). The Athensville Coal generally lies less than 10 feet below the Scottville Limestone. It occurs in southwestern Illinois, and it may correlate with the Lake Creek Coal of southern Illinois.

**Scottville Limestone Member**—The Scottville Limestone Member of the Modesto Formation (Payne, 1942, p. 4) is named for Scottville, Macoupin County. The type section consists of exposures along Apple Creek near the town (W1/2 SW 16, 12N-9W) (Wanless, 1956, p. 11). The Scottville Limestone occurs in southwestern Illinois, where it is as much as 3 feet thick. It is a light gray, fine-grained limestone that locally contains abundant *Osagia*, phylloid algae, and a diverse open-marine fauna. It is probably equivalent to part of the West Franklin Limestone of southeastern Illinois.

**Exline Limestone Member**—The Exline Limestone Member of the Modesto Formation (Cline, 1941, p. 65-66) is named for Exline, Appanoose County, Iowa, which is near the type section (SE 6, 67N-17W). The Exline occurs in western Illinois, where it is dark gray to black, thin- and even-bedded limestone that contains well preserved plant

stems and leaves, the worm tube *Spirorbis*, and a few marine pelecypods (Wanless, 1957, p. 120). In Iowa, the Exline contains a normal marine fauna. In Illinois it usually is less than 3 feet thick, is underlain by black fissile shale, and is overlain by gray marine shale. In some places the Exline lies immediately on the Lonsdale Limestone, but in others it is as much as 30 feet above the Lonsdale.

**Trivoli Sandstone Member**—The Trivoli Sandstone Member of the Modesto Formation (Wanless, 1931a, p. 182, 183, 190, 192), the top of which is the Desmoinesian-Missourian Series boundary, is named for Trivoli, Peoria County. The type section consists of exposures in a ravine northeast of Pea Ridge School, near Trivoli (SW 3, 9N-5E) (Wanless, 1956, p. 11; 1957, p. 121, 193). The Trivoli Sandstone is found both as a sheet facies generally less than 20 feet thick and as a channel facies that thickens to more than 80 feet, primarily at the expense of underlying strata (Andresen, 1961). The Trivoli is present throughout much of Illinois and marks one of the periods of major stream development during Pennsylvanian time in Illinois.

(Modesto Formation continued on page 196.)

## MISSOURIAN SERIES

The Missourian Series of the Pennsylvanian System (Keyes, 1893, p. 114-116; Moore, 1931) is named for the state of Missouri, where strata containing much limestone and a very little coal overlie the Desmoinesian rocks. In Illinois the Missourian includes rocks from the top of the Trivoli Sandstone Member up to a position a few feet below the coal that lies below the Shumway Limestone Member (Willman et al., 1967). It therefore includes the upper part of the Modesto Formation, all of the Bond Formation, and about half of the Mattoon Formation, all in the McLeansboro Group (fig. P-2).

Where fusulinids are present, as they are in many units in Illinois, the Missourian is characterized by earlier forms of the genus *Triticites*, which is the sub-genus *Kansanella* of Thompson. Floral zones are not as well defined in the Illinois Basin and the Midcontinent area, where the Missourian and overlying Virgilian together constitute Zones 11 and 12 (zone of *Odontopteris* sp.) (Read and Mamay, 1964). Delineation of the ranges of spore taxa in the Missourian and Virgilian Series has not been determined with the same degree of accuracy as is true for the remainder of the Pennsylvanian because the stratigraphic relation of many of the coals has not been worked out in detail. Small spores of ferns and seed ferns, many less than 30 microns in diameter, are prolific in most of the Missourian and Virgilian coals. The taxa are classified as *Punctatisporites minutus*, *Laevigatosporites minutus*, and species of *Cyclogranisporites* and *Apiculatisporis*. *Endosporites* is very abundant in many of the coals.

## Modesto Formation (continued)

**Chapel (No. 8) Coal Member**—The Chapel (No. 8) Coal Member of the Modesto Formation (Kosanke et al., 1960, p. 38), the oldest named unit in the Missouri Series, is named for Graham Chapel, Peoria County. It previously was called Trivoli (No. 8) coal (Wanless, 1931a, p. 181-182, 190, 192). The type section consists of exposures in a ravine northeast of Pea Ridge School, about 2 miles south of Graham Chapel (SW 3, 8N-5E) (Wanless, 1956, p. 11; 1957, p. 121, 193). The name "No. 8" was first given to this coal by Lesquerieux (1866, p. 213) for an exposure near Shawneetown, Gallatin County. Worthen (1870) also applied the name to this coal in outcrops near Springfield, Sangamon County. The Chapel Coal is a thin, bright-banded coal that is persistent throughout most of the area of the state that is underlain by the Modesto Formation. It occurs above the widespread Trivoli Sandstone or the West Franklin Limestone and is correlated with the Ditney Coal Member of southwestern Indiana.

**Cramer Limestone Member**—The Cramer Limestone Member of the Modesto Formation (Kosanke et al., 1960, p. 38) is named for Cramer, Peoria County. It previously was called Trivoli Limestone (Wanless, 1931a, p. 182, 190, 192). The type section consists of exposures in a ravine northeast of Pea Ridge School, 1.3 miles northeast of the village of Cramer (Wanless, 1956, p. 11; 1957, p. 121, 193). The Cramer Limestone is normally very argillaceous and is generally less than 1 foot thick. It is lenticular but widespread and is commonly found throughout the same area as the underlying Chapel (No. 8) Coal, from which it is commonly separated by 1-2 feet of black fissile shale. The Cramer contains an abundant open-marine fauna. It is correlated with the Sniabar Limestone of southern Iowa, Missouri, and eastern Kansas.

**Inglefield Sandstone Member**—The Inglefield Sandstone Member of the Modesto Formation (Fuller and Ashley, 1902, p. 3) is named for Inglefield, Vanderburgh County, Indiana, and the type locality consists of exposures in a railroad cut south of the town. The sandstone occurs above the Chapel (No. 8) Coal and below the Womac Coal (Andresen, 1961). It is known primarily in eastern Illinois, but it was reported by Andresen to split into two distinct sandstones in southwestern Illinois, the lower unit occurring below the Carlinville Limestone. The Inglefield Sandstone locally exceeds 80 feet in channels oriented south-southwest, but it is relatively widespread as a much thinner sheet sandstone in most of the Illinois Basin.

**Carlinville Limestone Member**—The Carlinville Limestone Member of the Modesto Formation (Worthen, 1873, p. 290-301) is named for Carlinville, Macoupin County. The type section consists of outcrops along Macoupin Creek (SW SW 35, 10N-7W) (Wanless, 1956, p. 11). The limestone is recognized only in part of southwestern Illinois, where it is thick-bedded, up to 5 feet thick, and contains an open-marine fauna.

**Burroughs Limestone Member**—The Burroughs Limestone Member of the Modesto Formation (Ball, in Cooper, 1946, p. 12; 1952, p. 37, 38, 85; Kosanke et al., 1960, p. 38) is named for Burroughs Branch, a tributary of Macoupin Creek, in Macoupin County. The type section consists of outcrops along the branch on the west side of Carlinville (NW SW 27, 10N-7W). The Burroughs is recognized in only a small area in west-central Illinois, where it is a dark gray, sandy, clastic limestone that contains crinoid columnals and brachiopods and ranges from a fraction of an inch to more than 5 feet thick. Its position is 14-17 feet above the Carlinville Limestone and 18 feet or less below the Macoupin Limestone.

**Womac Coal Member**—The Womac Coal Member of the Modesto Formation (Kosanke et al., 1960, p. 38) is named for Womac, Macoupin County. It previously was called the Macoupin Coal (Wanless, 1931b, p. 810-811). The type section consists of exposures in a ravine draining into Macoupin

Creek 3 miles southwest of Womac (Wanless, 1956, p. 11). This thin coal is widely traced in the Illinois Basin along with the overlying Macoupin Limestone, from which it is separated by 1-2 feet of black fissile shale. It is correlated with the Raben Branch Coal Member in Indiana.

**Macoupin Limestone Member**—The Macoupin Limestone Member of the Modesto Formation (Wanless, 1931b, p. 810-811) is named for Macoupin Creek in Macoupin County, along which the type section is exposed (NE NW 2, 9N-7W) (Wanless, 1956, p. 11; Ball, 1952, p. 85-86). It is a widespread unit, found throughout much of the Illinois Basin. The limestone is generally less than 2 but locally as much as 5 feet thick. In the type area it is composed of thin, even beds of crinoid limestone separated in places by shale partings. Most of it is dark gray and very argillaceous.

**Hall Limestone Member**—The Hall Limestone Member of the Modesto Formation (Willman, in Cooper, 1946, p. 12) is named for Hall Township, Bureau County. The type section consists of exposures in a ravine west of the coal mine refuse pile in the western part of the town of Spring Valley (NW SW 33, 16N-11E) (Wanless, 1956, p. 12). The Hall is recognized only in northern Illinois. In the type section it lies about 45 feet below the La Salle Limestone Member and consists of a 3-foot ledge of fine-grained, green, gray, and red limestone containing numerous brachiopods, crinoid columnals, and bryozoans. It is underlain by a persistent black shale. The Hall is correlated with the Macoupin Limestone of southern and eastern Illinois.

**New Haven Coal Member**—The New Haven Coal Member of the Modesto Formation (Kosanke, 1950, p. 88-89), the uppermost named member of the formation, is named for New Haven, Gallatin County. The type section is an outcrop along the Little Wabash River (SE SW SE 17, 7S-10E; incorrectly given as NW 19, 7S-10E, by Kosanke, 1950). The New Haven is a thin coal, generally separated by only 1-2 feet of black fissile shale from the overlying Shoal Creek Limestone Member of the Bond Formation. It is widespread in southeastern, southwestern, and central Illinois and is absent in parts of eastern Illinois. It is correlated with a thin coal below the La Salle Limestone in northern Illinois and with the Parker Coal Member of Indiana.

## Bond Formation

The Bond Formation of the McLeansboro Group (Kosanke et al., 1960, p. 39, 50, 70-73) is named for Bond County, where exposures are prominent. Seven separate outcrops in three counties constitute the type section (NE NE NE 3, 10N-2W, Montgomery County; SE NE 28, 12N-1W, Christian County; NE NW SE 7, 8N-2W, Montgomery County; east-central 24, 6N-5W, S1/2 7, 6N-4W, E edge 6, 7, 6N-4W, and SW NW 29, 7N-4W, Bond County). The Bond Formation varies from less than 150 feet thick in eastern Illinois to over 300 feet in southeastern Illinois and averages about 250 feet (fig. P-15). It includes all strata from the base of the Shoal Creek Limestone Member or the La Salle Limestone Member to the top of the Millersville Limestone Member or the Livingston Limestone Member (fig. P-2) and is characterized by a high percentage of limestone and calcareous clays and shales. The limestone members that bound the formation are the thickest and purest limestones in the Pennsylvanian System of Illinois. The upper limestone is as much as 50 feet thick and the lower is in places as much as 30 feet thick. Both are extensively quarried. In southern Illinois, south of the area of prominent development, there is no major single bench of the Millersville, and the equivalent strata are difficult to identify. Red claystones and

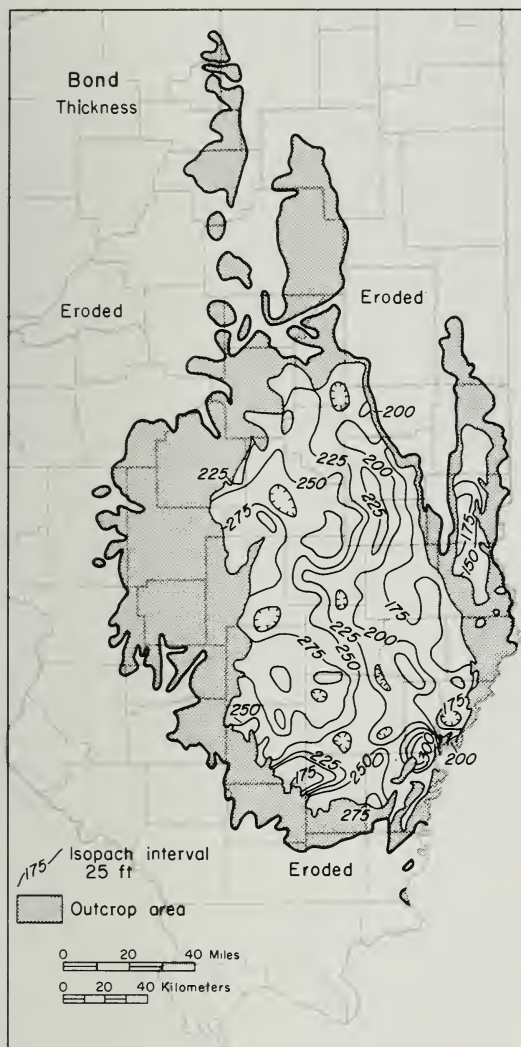


Fig. P-15—Thickness of the Bond Formation (based on map by K. E. Clegg).

shales are present in the Bond and are best developed in northern Illinois. Other units of the formation—gray shales, siltstones, and sandstones—are similar to those in the underlying Modesto Formation. Gray shales constitute the greatest portion of the formation, but thick channel sandstones are developed locally. The formation is also called Bond in Indiana, and it is equivalent to a portion of the Sturgis Formation in western Kentucky.

**Shoal Creek Limestone Member**—The Shoal Creek Limestone Member of the Bond Formation (Engelmann, 1868, p. 175, 177-183), the base of which is the base of the formation in all except northern Illinois, is named for Shoal Creek in Clinton County, and the type locality consists of exposures along the stream (3N-4W). The limestone is commonly 6-8 feet thick, locally as much as 20 feet. It is generally light gray, thick bedded, and fine grained, and it contains a diverse open-marine fauna. It persists throughout most of the Illinois Basin and is quarried in southwestern Illi-

nois. The Shoal Creek is an easily recognized marker on geophysical logs in most of the deeper part of the Illinois Basin. It is locally cut out by the Mt. Carmel Sandstone or the McWain Sandstone. It is correlated with the La Salle Limestone of northern Illinois, the lower part of the Winterset Limestone Member of Missouri, and the Carthage Limestone Member of western Kentucky. The Shoal Creek Limestone Member is also recognized in Indiana.

**La Salle Limestone Member**—The La Salle Limestone Member of the Bond Formation (Cady, 1908, p. 128-134), the base of which is the base of the formation in northern Illinois, is named for La Salle, La Salle County. The type section consists of exposures near Bailey's Falls, south of La Salle (14, 33N-1E) (Wanless, 1956, p. 12). The La Salle Limestone is well developed in northern Illinois, where it has been quarried extensively (Cady, 1919b). It is as much as 30 feet thick in exposures near La Salle along the west flank of the La Salle Anticline, but it thins westward to about 12 feet west of Spring Valley, Bureau County. In a belt 1-2 miles wide along its eastern margin, it is a fine-grained, thick-bedded, light gray, nodular limestone containing a few shale partings and a large and diverse marine fauna, mainly brachiopods and gastropods. It grades westward to a fine-grained, argillaceous, tan, brown-weathering limestone that occurs mostly in even beds 4-8 inches thick separated by strong shale partings and containing a restricted marine fauna characterized by large brachiopods, mostly productids. It formerly was correlated with the Millersville and Livingston Limestone Members but is now correlated with the Shoal Creek Limestone.

**McWain Sandstone Member**—The McWain Sandstone Member of the Bond Formation (Ball, 1943, p. 150) is named for the McWain Farms, Macoupin County. The type section consists of exposures along Macoupin Creek (SE 25, 10N-7W) (Ball, 1952, p. 44). The McWain occurs as a channel sandstone in southwestern Illinois, where it locally rests on the Shoal Creek Limestone or on strata between the Shoal Creek and the Macoupin Limestone. It has been correlated with the Mt. Carmel Sandstone.

**Mt. Carmel Sandstone Member**—The Mt. Carmel Sandstone Member of the Bond Formation (Worthen, 1875, p. 52, 55) is named for Mt. Carmel bluff on the Wabash River at Mt. Carmel, Wabash County (W $\frac{1}{2}$  21, 1S-12W). The Mt. Carmel Sandstone is well developed in eastern and southeastern Illinois, where it is the first major channel sandstone above the Shoal Creek Limestone, and it is as much as 80 feet thick in places. It occurs about 10 feet below the Flannigan Coal. The Mt. Carmel Sandstone has been correlated with the McWain Sandstone of southwestern Illinois.

**Sorento Limestone Member**—The Sorento Limestone Member of the Bond Formation (Simon, in Wanless, 1955, p. 1764) is named for Sorento, Bond County. The type section consists of outcrops along the south-flowing tributary of Dry Fork just southwest of Sorento (NE NE 6, 6N-4W) (Kosanke et al., 1960, p. 39). The Sorento Limestone and the underlying unnamed coal have been recognized throughout much of the Illinois Basin. The limestone is generally fine grained, medium gray, less than 2 feet thick, and contains an open-marine fauna composed primarily of brachiopods, crinoids, and gastropods. In southwestern Illinois the Sorento generally lies 15-20 feet above the Shoal Creek Limestone. In the deeper part of the Illinois Basin the interval is usually 20-40 feet, but locally it may be as much as 100 feet. The Sorento is tentatively correlated with the Little Vermilion Limestone of northern Illinois.

**Little Vermilion Limestone Member**—The Little Vermilion Limestone Member of the Bond Formation (Willman, in Cooper, 1946, p. 14) is named for the Little Vermilion River in La Salle County along which the type section is exposed (SW SW 11, 33N-1E) (Wanless, 1956, p. 12). The Little Vermilion Limestone lies about 25 feet above the La Salle Limestone and is as much as 4 feet thick locally. The limestone is dark gray, argillaceous, and shaly. It is very fossiliferous.

ferous, with brachiopods (particularly *Rhipidomella*), bryozoans, and crinoids abundant. In the type area a coal, generally less than 1 foot thick, is found about a foot below the limestone. The Little Vermilion is tentatively correlated with the Sorento Limestone.

**Bunje Limestone Member**—The Bunje Limestone Member of the Bond Formation (Simon, *in* Kosanke et al., 1960, p. 39) is named for Bunje Station, Bond County, and the type section is about 1 mile south, along Dry Fork (SE SW 7, 6N-4W). The Bunje is known only in the type locality, where it is generally less than 2 feet thick. It is very fossiliferous, having a fauna dominated by large pelecypods, and the upper few inches is characterized by cone-in-cone structure. It is underlain by an unnamed sandstone unit and is commonly about 40 feet above the Sorento Limestone. The Bunje is separated from the Flat Creek Coal above by a few feet of shale and underclay.

**Flat Creek Coal Member**—The Flat Creek Coal Member of the Bond Formation (Simon, *in* Wanless, 1955, p. 1764) is named for Flat Creek in Bond County, along which the type section is exposed (NE SE 24, 6N-5W) (Kosanke et al., 1960, p. 39). The Flat Creek is a thin, widespread coal readily recognized on geophysical logs in southwestern Illinois. The coal is widely overlain by a thin black shale and a marine limestone. It is correlated with the Flannigan Coal of southeastern and eastern Illinois and the Fairbanks Coal Member of Indiana.

**Flannigan Coal Member**—The Flannigan Coal Member of the Bond Formation (Newton and Weller, 1937, p. 9) is named for Flannigan Township, Hamilton County, where the type section is an exposure along a southwest-flowing tributary of the Middle Fork Saline River (SW NE 17, 7S-SE; erroneously reported as 6S-SE by Kosanke et al., 1960). In the type area, the Flannigan Coal is about 1 foot thick and is overlain by a thin, black fissile shale. The Flannigan occurs in southeastern and eastern Illinois and is correlated with the Flat Creek Coal of southwestern Illinois.

**Reel Limestone Member**—The Reel Limestone Member of the Bond Formation (Worthen, 1875, p. 55) is named for Reel's Corner, Wabash County (NE? 8, 1S-12W). The Reel Limestone occurs in eastern and southeastern Illinois where it is the first limestone above the Shoal Creek Limestone and lies 85-100 feet above it. The Reel Limestone is dark gray, contains many small gastropods, pelecypods, brachiopods, and incrusting Foraminifera, and is 1-3 feet thick. It is generally underlain by a thin, black fissile shale that directly overlies the Flannigan Coal.

**Witt Coal Member**—The Witt Coal Member of the Bond Formation (Gluskoter, *in* Kosanke et al., 1960, p. 43) is named for Witt, Montgomery County. The type section consists of exposures along the East Fork of Shoal Creek, about 6.5 miles south of Witt (NE NW SE 7, 8N-2W). The Witt Coal is generally less than 1 foot thick and is recognized only in southwestern Illinois. In the Witt type area the coal lies approximately 45 feet above the Flat Creek Coal. It has been tentatively correlated with a persistent, unnamed, thin coal that occurs about 35 feet above the Reel Limestone throughout eastern and southeastern Illinois.

**Coffeen Limestone Member**—The Coffeen Limestone Member of the Bond Formation (Gluskoter, *in* Kosanke et al., 1960, p. 39) is named for Coffeen, Montgomery County, and the type section consists of outcrops along the East Fork of Shoal Creek, about 4.5 miles northeast of Coffeen (NE NW SW 7, 8N-2W). The Coffeen Limestone is less than 2 feet thick in the type area and contains a varied marine fauna dominated by brachiopods, crinoids, and bryozoans. It is 8 feet above the Witt Coal in the type area and may be fairly widespread, but it has been recognized only in the northern part of southwestern Illinois. It occurs about 80 feet below

the base of the Millersville Limestone. The Coffeen Limestone probably correlates with the Riverview Limestone Member, which lies about 40 feet above the Fairbanks Coal Member of Indiana.

**Millersville Limestone Member**—The Millersville Limestone Member of the Bond Formation (Taylor and Cady, 1944, p. 22), the top of which defines the top of the formation in central and southern Illinois, is named for Millersville, Christian County. The type locality consists of exposures near the village (SE NE 28 and NW NW 31, 12N-1W) (Payne and Cady, 1944, p. 12-13). In the type area the Millersville is 50 feet thick and is divided into two or three benches by shale partings as much as 2-3 feet thick. It is the thickest limestone in the Pennsylvanian System in Illinois. The limestone is light gray, fine grained, and contains a diversified open-marine fauna. The Millersville has been extensively quarried in central Illinois. In southern Fayette, Effingham, and Jasper Counties and farther south it is not well developed, although thin limestones in that area are considered as correlatives of part of the Millersville. East of the La Salle Anticlinal Belt, the Livingston Limestone is correlated with the Millersville, as is the Argentine Limestone Member of Missouri.

**Livingston Limestone Member**—The Livingston Limestone Member of the Bond Formation (Worthen, 1875, p. 11-19), the top of which forms the top of the formation in eastern Illinois, is named for Livingston, Clark County. The type section consists of exposures along Big Creek, about 2 miles northwest of Livingston (SE NW 6, 11N-11W) (Wanless, 1956, p. 12). The Livingston occurs in two or three benches separated by shale beds 1-6 feet thick and has a maximum thickness of about 25 feet. It is generally fine grained and medium to thick bedded, and each bench thins to the south as the shale partings become thicker. The Livingston is well developed in Vermilion, Edgar, Clark, and eastern Coles Counties, where it has been extensively quarried. It thins southward into Crawford County. The Livingston is correlated with the Millersville Limestone west of the La Salle Anticlinal Belt.

## Mattoon Formation

The Mattoon Formation of the McLeansboro Group (Kosanke et al., 1960, p. 39, 40), the youngest Pennsylvanian formation in Illinois, is named for Mattoon, Coles County, which lies in the general outcrop area of the formation. No type section has been designated, but a good reference section of the lower 300 feet of the formation is available in a detailed sample study and an electrical log for the Illinois Geological Survey Coal Section control well 191, an oil test boring in Clay County (SE SE SE 10, 4N-5E) on file at the Survey (Kosanke et al., 1960, p. 40, 83, 84). The formation is underlain by the Bond Formation (fig. P-2), and the top is an erosional surface overlain, for the most part, by Pleistocene glacial deposits. A maximum of slightly more than 600 feet of Mattoon is preserved in the central part of the Illinois Basin in Jasper County (fig. P-16). Lithologically the Mattoon Formation is a complex unit of thin limestones, coals, black fissile shales, underclays, thick gray shales, and several well developed sandstones. Outcrops are widely scattered, and reliable subsurface data, except for electrical logs of oil tests, are scarce. Consequently, the lateral extent of many of the named units has not been determined. However, many of the coals and limestone units in the Mattoon are believed to be no less persistent than others in the McLeansboro Group. The Omega and Greenup Limestone Members are well developed and

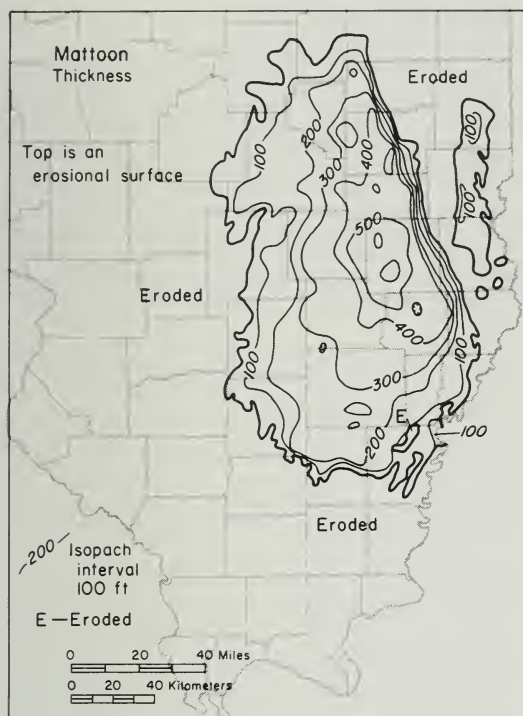


Fig. P-16—Thickness of the Mattoon Formation (based on map by K. E. Clegg).

contain abundant marine fossils, but others are thin and argillaceous. A few tan argillaceous limestones, which contain only ostracodes and *Spirorbis*, are usually less than 5 feet thick. The lower 150 feet of the Mattoon extends into Indiana. The Mattoon correlates with the upper part of the Sturgis Formation in western Kentucky but the top several hundred feet of the Sturgis is younger than the youngest Mattoon of Illinois.

**Friendsville Coal Member**—The Friendsville Coal Member of the Mattoon Formation (Fuller and Clapp, 1904, p. 2) is named for Friendsville, Wabash County. The type locality consists of several abandoned mines near Friendsville (13, 24, 1N-13W) (Kosanke, 1950, p. 89). The Friendsville Coal is present only in the western two-thirds of Wabash County, where it is as much as 4 feet thick. Near McCleary's Bluff in southern Wabash County it is overlain by an unnamed lenticular limestone up to 6 feet thick that contains abundant phylloid algae. The Friendsville Coal lies about 160 feet above the Reel Limestone, and its position is thought to be in the lower part of the Mattoon Formation. However, its exact relation to the Millersville (Livingston) Limestone has not been determined. In Wabash County, strata that may be equivalent to the Millersville are a complex of limestone, shale, and a few coal streaks, one of which may be equivalent to the Friendsville Coal.

**Cohn Coal Member**—The Cohn Coal Member of the Mattoon Formation (Newton and Weller, 1937, p. 18) is named for Cohn (now called Livingston), Clark County. The type section consists of an exposure on the south side of Big Creek, about 2.5 miles from Livingston (NE 1, 11N-12W). The Cohn Coal occurs in eastern Illinois, where it is generally

less than 10 inches thick. At its type locality it is only 2 inches thick, and it lies 22 feet above the Livingston Limestone and 12 feet below the base of the Merom Sandstone. A 16-inch thick nodular limestone containing numerous *Spirorbis* occurs 2 feet above the coal. To the south in Crawford County, the Cohn Coal is correlated with a thin coal that has been mined in the vicinity of Flat Rock. In that area the Cohn Coal lies at or very near the base of the Merom Sandstone, which may have eroded the coal in some areas.

**McCleary's Bluff Coal Member**—The McCleary's Bluff Coal Member of the Mattoon Formation (Kosanke, 1950, p. 89; Kosanke et al., 1960, p. 40, 51) is named for McCleary's Bluff, Wabash County. The type section consists of a 3-inch coal seam exposed on the bluff overlooking the Wabash River (NW SW SE 29, 2S-13W). Its stratigraphic position is approximately 50 feet above the Friendsville Coal (Kosanke et al., 1960). It was erroneously placed below the Friendsville Coal by Kosanke (1950) and Siever (*in* Wanless, 1956). The only known exposures of the McCleary's Bluff Coal occur on McCleary's Bluff and at Keys Hill in Wabash County (NE SW 25, 1S-13W). An unnamed coal member approximately 1 foot thick lies 7 feet above the McCleary's Bluff Coal in its type area.

**Merom Sandstone Member**—The Merom Sandstone Member of the Mattoon Formation (Collett, 1871, p. 199) is named for Merom Hill, Sullivan County, Indiana, and the type section is along the Wabash River Bluff near the town of Merom (7, 7N-10W). At the type locality the Merom Sandstone occurs directly below glacial drift and has a maximum observed thickness of approximately 55 feet. It lies directly on top of a limestone 2-4 feet thick, which is correlated with the Livingston Limestone of eastern Illinois. The sandstone is dominantly a fluvial channel deposit, and at its type locality it has eroded the Cohn Coal, which normally lies 20-30 feet above the Livingston Limestone. The Merom Sandstone is the uppermost named member of the Pennsylvanian System in the Marshall Syncline (fig. 12), where it is approximately 100 feet thick. The stratigraphic position of the Merom Sandstone has not been definitely determined.

**Dix Limestone Member**—The Dix Limestone Member of the Mattoon Formation (Bradbury, 1965, p. 4) is named for Dix, Jefferson County, where it has been quarried locally. The type section consists of exposures on a southwest-flowing tributary to Casey Fork, about 2 miles south of Dix (NW SE NW 25, 1S-2E). In that area the Dix is a brownish gray argillaceous limestone as much as 6 feet thick that contains only *Spirorbis* and numerous ostracodes. It lies about 50 feet above the position of the Millersville Limestone and 300 feet above the Shoal Creek Limestone. The Dix may correlate with the fresh-water limestone found at the base of the underclay below the Opdyke Coal.

**Opdyke Coal Member**—The Opdyke Coal Member of the Mattoon Formation (Cady et al., 1952, p. 90-91) is named for the village of Opdyke, Jefferson County, where the type section is in small mines in the vicinity of Belle Rive and Opdyke (3S-4E). In the type locality the Opdyke is fairly extensive and as much as 2 feet thick locally. It crops out in eastern and southeastern Jefferson County and northwestern Hamilton County. It lies about 430 feet above the Shoal Creek Limestone and is tentatively correlated with a 12-inch coal that crops out on the Loudon Anticline in eastern Fayette County, 60-70 feet above the Millersville Limestone, and is believed to be extensive in the subsurface of central Illinois.

**Shelbyville Coal Member**—The Shelbyville Coal Member of the Mattoon Formation (Broadhead, 1875, p. 169-171, used the term "Shelby"; Worthen, 1875, p. 49, used the term "Shelbyville") is named for Shelbyville, Shelby County. The type section is in natural exposures and in drift and shaft mines in the vicinity of Shelbyville (11N-3-4E) (Kay.

1915, p. 215, 216). The coal is locally as much as 3 feet thick and can be traced in the subsurface in most of the area in which the Mattoon Formation occurs. It is normally 80-120 feet below the Omega Limestone.

**Calhoun Coal Member**—The Calhoun Coal Member of the Mattoon Formation (Noé, 1934, p. 103) is named for Calhoun, Richland County, and the type section is in a roadcut about 2 miles southeast of Calhoun (NE NE 6, 2N-14W) (Kosanke et al., 1960, p. 40, 82). The Calhoun Coal is widespread in eastern Illinois, where it is 2 feet thick or less and is overlain by the Bonpas Limestone. It lies about 525 feet above the Shoal Creek Limestone. The Calhoun is also present on the western side of the deeper part of the Illinois Basin, where it occurs a foot or two below the Omega Limestone.

**Omega Limestone Member**—The Omega Limestone Member of the Mattoon Formation (Weller and Wanless, in Lamar et al., 1934, p. 128) is named for Omega, Marion County. The type locality consists of exposures in an abandoned limestone quarry (NW NW NE 30, 3N-4W) (Weller and Bell, 1936, p. 29-32; Wanless, 1956, p. 12; Kosanke et al., 1960, p. 81, 82). The Omega is almost 11 feet thick in the type locality and reaches 15 feet in Effingham and Shelby Counties. In Shelby County it varies in thickness and character and is very argillaceous and sandy in areas where it is thick. Although sporadic in occurrence, it appears in a wide area. It is correlated with the Bonpas Limestone in eastern Illinois.

**Bonpas Limestone Member**—The Bonpas Limestone Member of the Mattoon Formation (Kosanke et al., 1960, p. 41) is named for Bonpas Creek, Richland County. It previously was called Calhoun Limestone (Weller, in Dunbar and Henbest, 1942, p. 27). The type section is in a roadcut exposure about 1.5 miles west of Bonpas Creek, the same location as the Calhoun Coal type section (Kosanke et al., 1960, p. 41, 82). The Bonpas is 3 feet thick in the type locality and is widely distributed in eastern Illinois. It contains a varied open-marine fauna and is correlated with the Omega Limestone of the western side of the area covered by the Mattoon Formation.

(Mattoon Formation continued in next column)

## VIRGILIAN SERIES

The Virgilian Series of the Pennsylvanian System (Moore, 1931, correlation chart) is named for Virgil, Greenwood County, Kansas, which lies in the outcrop belt of these rocks. In Illinois it includes all Pennsylvanian strata above a position a few feet below the coal that occurs just below the Shumway Limestone Member (Willman et al., 1967). It thus includes the upper half of the Mattoon Formation of the McLeansboro Group (fig. P-2). Where marine rocks are found, as they are in Illinois and the Midcontinent Region, the Virgilian includes strata containing fusulinids of the genus *Triticites* that are more advanced than the subgenus *Kansanella* found in lower strata. The upper limit is placed just below the first appearance of the Permian genera *Pseudoschwagerina* and/or *Schwagerina*, but neither have been found in the Illinois Basin. The spores and plant-compression fossils in Virgilian rocks are not well known.

## Mattoon Formation (continued)

**Shumway Limestone Member**—The Shumway Limestone Member of the Mattoon Formation (Weller, in Dunbar and Henbest, 1942, p. 28; Wanless, 1956, p. 12) is named for Shumway, Effingham County. The type locality consists of exposures along Shoal Creek about 2 miles east of Shumway (SE SE SW 26, 9N-5E) (Kosanke et al., 1960, p. 81). The Shumway is the upper, most persistent of two marine limestones. At the type locality it is 2 feet thick and contains an abundant open-marine fauna dominated by brachiopods and containing a few solitary corals. The Shumway and the thin coal a few feet under it are exposed in Effingham County. It is directly underlain by a black fissile shale and overlain by gray shale.

**Effingham Limestone Member**—The Effingham Limestone Member of the Mattoon Formation (Wanless, 1956, p. 7, 12) is named for Effingham, Effingham County. The type section consists of outcrops in the east-flowing tributary to Salt Creek just south of Effingham (S line NW 33, 8N-6E). This limestone has not been recognized far from the type area, where it is a 1-foot bed of granular conglomeratic limestone containing numerous brachiopods, gastropods, crinoids, and a few corals. A thin, black fissile shale occurs about 3 feet above the Effingham Limestone.

**Trowbridge Coal Member**—The Trowbridge Coal Member of the Mattoon Formation (Cady, 1948, p. 5, footnote 4) is named for Trowbridge, Shelby County. The type locality consists of outcrops about 1 mile northeast of the town (S line 11, 10N-6E). The Trowbridge attains a maximum thickness of 2.5-3 feet and is a normally banded coal that is high in ash. It occurs about 150-180 feet above the Omega Limestone. It has not been traced far from the type area.

**Bogota Limestone Member**—The Bogota Limestone Member of the Mattoon Formation (Newton and Weller, 1937, p. 9) is named for Bogota, Jasper County. The type section consists of exposures along Big Muddy Creek about 6 miles southwest of Bogota (NE NE 7, 5N-8E) (Kosanke et al., 1960, p. 44, 79, 80). The Bogota is known definitely only in the type locality, but the name has been questionably applied to many limestone outcrops in the central part of the area of the Mattoon Formation. In the type section the Bogota is 1.5 feet of gray, fossiliferous, nodular limestone in a yellowish brown clay matrix, and it overlies about 1 foot of black fissile shale.

**Reisner Limestone Member**—The Reisner Limestone Member of the Mattoon Formation (Kosanke et al., 1960, p. 41, 51) is named for Reisner School, Jasper County. It previously was called Newton Limestone (Newton and Weller, 1937, p. 9, 24-25). The type section consists of exposures along West Crooked Creek, 1.5 miles northeast of the abandoned Reisner School (NE NE 16, 7N-10E). Near its type locality the Reisner Limestone is argillaceous and contains fragments of small brachiopods. It is generally less than 1 foot thick, is overlain by 1.5 feet of black fissile shale, and is underlain by claystone containing argillaceous and generally unfossiliferous (with local exceptions of *Spirorbis*) limestone as much as 3 feet thick in places. The Reisner Limestone lies 60-80 feet above the Bogota Limestone Member and 40-45 feet above an unnamed coal that was mined from a few shallow shafts in the vicinity of Newton and was reported to be approximately 2 feet thick. Kosanke et al. (1960) stratigraphically placed the Reisner Limestone as the youngest named member in the Mattoon Formation. However, recent studies indicate that the Reisner Limestone occurs below the Greenup Limestone, as had been stated by Newton and Weller (1937).

**Gila Limestone Member**—The Gila Limestone Member of the Mattoon Formation (Newton and Weller, 1937, p. 27) is named for Gila, Jasper County. The type section consists of exposures about 1.5 miles south of Gila along Mint Creek (NE SW 31, 8N-9E) (Kosanke et al., 1960, p. 41, 51, 78,

79). The Gila has not been recognized outside the type area, where it is a gray, fine-grained, dense limestone 2.5 inches thick in which fish scales and teeth are the only fossils found.

**Woodbury Limestone Member**—The Woodbury Limestone Member of the Mattoon Formation (Newton and Weller, 1937, p. 9, 28-30) is named for Woodbury, Cumberland County. The type section consists of exposures on a tributary to Webster Branch about 2 miles southwest of Woodbury (S $\frac{1}{2}$  SE 32, 9N-8E). In the type section the Woodbury is a hard, gray, calcareous ironstone layer 3-4 inches thick that contains numerous brachiopods, crinoids, and a few corals. It is separated from an underlying 5-inch coal by a few inches of black coaly shale. The Woodbury has not been recognized outside the type area.

**Greenup Limestone Member**—The Greenup Limestone Member of the Mattoon Formation (Newton and Weller, 1937, p. 9, 26), the youngest named member of the formation, is named for Greenup, Cumberland County. The type section consists of exposures along the valley wall of the Embarras River just west of Greenup (cen. W $\frac{1}{2}$  NE 3, 9N-9E) (Kosanke et al., 1960, p. 41, 51, 79). The Greenup is known from several outcrops in the northern part of the area of the Mattoon Formation in Jasper, Cumberland, and Coles Counties, where it is as much as 8 feet thick and has been quarried locally. The Greenup is a relatively pure limestone with an abundant open-marine fauna dominated by brachiopods and crinoids but also including a few corals and locally abundant fusulinids. It represents a major marine transgression into Illinois.

## MESOZOIC ERATHEM

*H. B. Willman and John C. Frye*

The Mesozoic Erathem—the rocks deposited during the Mesozoic Era (Phillips, 1840)—is represented in Illinois only by the Cretaceous System, the youngest deposits of the era. As the youngest of the Paleozoic rocks (the Permian System), the Mesozoic, Triassic, and Jurassic Systems and the Comanchean Series of the Cretaceous System are not represented in Illinois, the base of the Cretaceous System is a major unconformity (fig. 1). However, the general distribution of the marine Permian rocks over the continental United States suggests that Permian seas covered much of Illinois and that their absence is attributable to erosion, either in latest Permian time or during the early and middle parts of the Mesozoic Era. There is no evidence to suggest that extensive deposits, either marine or continental, accumulated in Illinois during the pre-Cretaceous periods of the Mesozoic Era. Although such deposits could have been present and entirely eroded, the development of the sub-Cretaceous unconformity required a long interval of erosion, and it seems likely that Illinois was continuously in an erosional environment during early Mesozoic time. The Little Bear Soil, which developed on the Paleozoic rocks and is present at the base of the Cretaceous sediments in southern Illinois (fig. K-2), probably formed during the later part of this interval.

The Mesozoic rocks, which are largely unconsolidated sand incorporating some silt and clay, occur only in extreme southern Illinois and locally in western Illinois (figs. K-3, K-

4). The southern Illinois Cretaceous strata are part of the deposits at the head of the Mississippi Embayment of the Gulf Coastal Plain. With the overlying Tertiary formations, they compose a distinctive unit differentiated as the Embayment Megagroup.

The Mesozoic Era, the interval of "middle life," formerly called the "Secondary Group" of rocks, is also known as the Age of Reptiles, and the huge dinosaurs of that time may have been common in Illinois, although no remains have been found. The era also saw the first appearance of birds, mammals, and angiosperms.

### *Little Bear Soil*

The Little Bear Soil (Mellen, 1937, p. 8-20), a soil locally preserved at the base of the Cretaceous System, is named for Little Bear Creek, Tishomingo County, Mississippi. It is the only soil-stratigraphic unit that has been named in Illinois in pre-Quaternary strata (Pryor and Ross, 1962; Ross, 1963). It consists of remnants of an iron-rich residual soil developed on Paleozoic rocks. Isolated remnants have been found throughout the eastern part of the Mississippi Embayment. In Illinois it consists of red and brown clays with lenses and nodules of brown to black limonite and, generally, a few angular chert pebbles. It is included in the lower part of the Tuscaloosa Formation. It is well exposed along the Post Creek Cutoff in Pulaski County (cen. 2, 15S-2E), where it is 7 feet thick, rests on the St. Louis Limestone, and is overlain by gravel of the Tuscaloosa Formation. The Little Bear Soil was developed during early Cretaceous time, after the erosional truncation of the Paleozoic rocks by the sub-Cretaceous unconformity.

## EMBAYMENT MEGAGROUP

The Embayment Megagroup (Swann and Willman, 1961, p. 482), named for the Mississippi Embayment, the northward extension of the Gulf Coastal Plain into southernmost Illinois, consists in Illinois of the dominantly clastic formations of Cretaceous and Tertiary age that differ markedly in character from the underlying Paleozoic and the overlying Quaternary formations and are separated from

both by major unconformities. The Embayment Megagroup includes seven formations (figs. K-2, T-2) that occur largely south of the Cache Valley in Pulaski and Massac Counties but also extend westward across Alexander County from the Cache River Valley to the Mississippi River Valley. The megagroup thickens rapidly southward into the Embayment area and has a maximum thickness of nearly 1000 feet in subsurface near Cairo, Alexander County.

## CRETACEOUS SYSTEM

The Cretaceous System (D'Hallo, 1822), named for the chalk formations of France, is restricted in Illinois to five counties in extreme southern Illinois and to areas in Pike and Adams Counties in western Illinois.

The Cretaceous rocks in southern Illinois (Glenn, 1906; Lamar and Sutton, 1930; Stearns, 1958; Pryor, 1960; Pryor and Ross, 1962; Ross, 1963, 1964) (figs. K-1, K-2) are at the north end of the Mississippi Embayment of the Gulf Coastal Plain (fig. K-3). They are entirely clastic rocks—the nonmarine part of a large delta built where a river from the east discharged into the head of the embayment. A thin marine deposit occurs at the top. The Cretaceous rocks are as much as 500 feet thick near Cairo, where they are overlain by Paleocene sediments, but they thin rapidly northward as they are truncated by younger Tertiary and Pleistocene sediments.

The Cretaceous rocks in western Illinois (Frye et al., 1964) (fig. K-4) also are clastic rocks, largely sand, and as much as 100 feet thick. They are the easternmost outliers of Cretaceous sediments that formerly covered the region east of the Rocky Mountains and north of the Ozarks. The outliers in Illinois are nearly 200 miles from the nearest Cretaceous exposures in west-central Iowa. They appear to be beach and nearshore sediments deposited in the advancing Cretaceous sea.

Although the deposits are dominantly quartz sand in both areas, they differ noticeably in other mineral constituents. The two regions were separated by a barrier, probably a low eastern extension of the Ozark Uplift across southern Illinois.

The Cretaceous sediments in southern Illinois terminate northward as they are truncated by Tertiary deposits. The presence of Creta-

ceous-type gravel and white clays in possible sink holes as far north as Kaolin, northwest of Anna, Union County, suggests that Cretaceous deposits formerly were more extensive than they are now, although they probably did not extend significantly north of their present area. Cretaceous rocks in western Illinois terminate southward against an area of higher Mississippian formations, indicating that Cretaceous sediments may never have been deposited in the area between there and extreme southern Illinois.

The southern Illinois Cretaceous rocks are largely nonmarine sand containing beds of lignitic silt and clay, lignite, and gravel. The major part of the Cretaceous in this area is assigned to the McNairy Formation, but the patches of gravel at the base are assigned to the Tuscaloosa Formation, and a thin, marine sandy silt at the top is assigned to the Owl Creek Formation (fig. K-2). The heavy minerals of the sands are characterized by a high content of kyanite and by appreciable amounts of staurolite, tourmaline, sillimanite, zircon, and rutile. The clay minerals in the nonmarine sediments are largely kaolinite, whereas those in the marine sediments are dominantly montmorillonite (Pryor and Glass, 1961). The mineralogy indicates the sediments were derived from the metamorphic rocks of the Piedmont region to the east or southeast. The sediments were carried into the Embayment region by a river on the sub-Cretaceous erosional surface.

Cretaceous rocks in western Illinois, all assigned to the Baylis Formation, are largely sand and clayey sand that are generally nearly white, although they are rusty brown where weathered. They commonly contain a bed of gravel at the base and, in some localities, beds of gray to dark gray silty clay. The heavy minerals in the sands are dominantly

zircon, tourmaline, and staurolite, in percentages close to those in the Cretaceous deposits of Iowa and Kansas. The dominant clay mineral varies from bed to bed, from montmorillonite to illite to kaolinite, indicating the mixed compositions of nearshore environments and derivation largely from northern sources. Similar compositions were found in samples of the Cretaceous in Iowa. The mineral composition and sediment characteristics distinguish these deposits from glacial deposits.

The Cretaceous rocks in western Illinois appear to have been deposited on a nearly flat surface eroded across various Mississippian and Pennsylvanian formations. In southern Il-

linois, variations in thickness of the Cretaceous sediments have commonly been interpreted as indicating significant relief on the pre-Cretaceous surface because the outcropping Cretaceous rocks show none of the intensive faulting found in the Paleozoic rocks immediately north of the Cretaceous area. However, Ross (1963) questioned this interpretation because subsurface information showed that the basal thin gravel and the Little Bear Soil beneath it are more widespread than originally thought and that the thickness variations of the Cretaceous parallel the structures in the Paleozoic rocks. Consequently, he related the irregularities of the sub-Cretaceous surface to Cretaceous and possibly post-Cretaceous movements of some of the major faults.

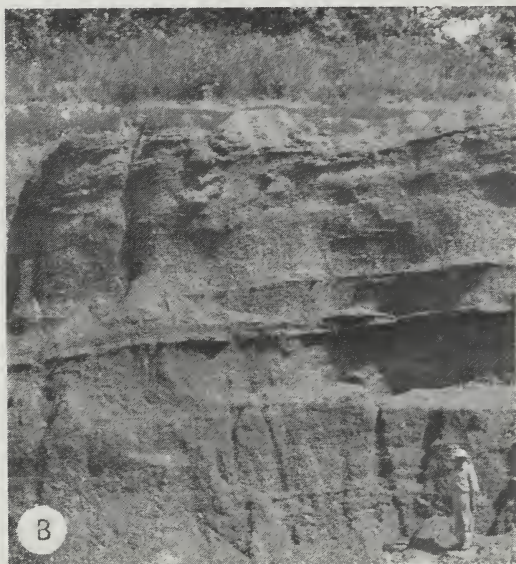
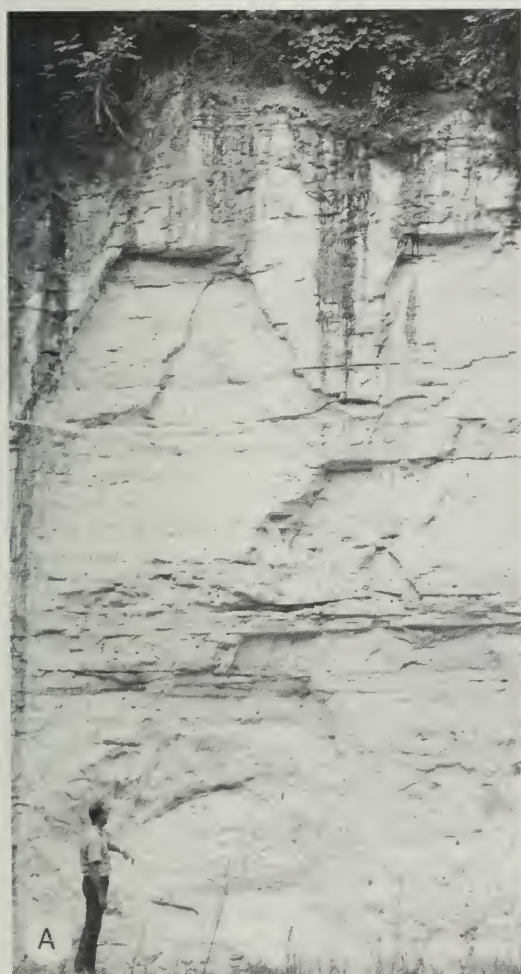


Fig. K-1—Exposures of Cretaceous and Tertiary rocks.

A—McNairy Sand in a pit near Fayville, Alexander County.

B—Mounds Gravel in pit along Illinois Highway 145, 8 miles north of Metropolis, Massac County.

C—Bedding surface of Mounds Gravel in same pit as exposure B ( $\times 1\frac{1}{2}$ ).

The Cretaceous age of the southern Illinois deposits is indicated by the presence of a few distinctive Foraminifera in the Owl Creek Formation, by abundant plant fossils in the lignitic beds, and by the equivalence of the deposits to the abundantly fossiliferous marine sediments south of Illinois. No fossils have been found in the western Illinois deposits, but the composition of the gravels, the heavy minerals in the sands, and the clay mineral assemblages are all similar to those of the Cretaceous rocks in Iowa. From their stratigraphic position, the sediments could be Tertiary in age, but they appear to have been deeply eroded before the near-by late Tertiary gravel was deposited.

GULFIAN SERIES

The Gulfian Series (Hill, 1887, p. 298, 300) is named for its occurrence along the Coastal Plain of the Gulf of Mexico, and is presumed to include all Cretaceous rocks in Illinois. In southern Illinois most of the Cretaceous rocks were deposited during the youngest part of the Gulfian, although the basal Tuscaloosa Formation may represent early deposits of the series. Cretaceous rocks in western Illinois were probably deposited during early Gulfian time.

Tuscaloosa Formation

The Tuscaloosa Formation (Smith and Johnson, 1887, p. 18, 95-117) (fig. K-2), is named for exposures along the Tuscaloosa (Black Warrior) River near Tuscaloosa, Alabama. It is exposed only locally in extreme southern Illinois and appears to have a patchy distribution (Pryor, 1960; Pryor and Ross, 1962; Ross, 1964). It has a maximum thickness of 20 feet but is generally much thinner. The Tuscaloosa is well exposed along the Post Creek Cutoff, Pulaski County (cen. 2, 15S-2E), and in railroad cuts in the Thebes Gorge, 1 mile south of Rock Springs Hollow, Alexander County (SW 21, 15S-3W). It is largely chert gravel, generally moderately cemented with fine silica or white clay. The chert pebbles, in a matrix of coarse quartz sand, are mainly white or gray, but black pebbles are locally common. Beds of pebbly sand and white clay also are common. The clays are dominantly kaolinite (Pryor and Glass, 1961). The Little Bear Soil occurs in deposits at the base of the Tuscaloosa Formation. Gravel found northeast of Elco in northern Alexander County (SW SE 7, 14S-1W) is probably Tuscaloosa Gravel preserved in sink holes. Local concentrations of gray and black chert pebbles on the upland bedrock surfaces as far north as Kaolin, Union County (SW NW 2, 12S-2W), are probably residual or reworked from the Tuscaloosa. The Tuscaloosa in Illinois is similar in lithology and stratigraphic position to the Tuscaloosa of Kentucky and Tennessee, but it is a transgressive deposit and may be younger than the type Tuscaloosa.

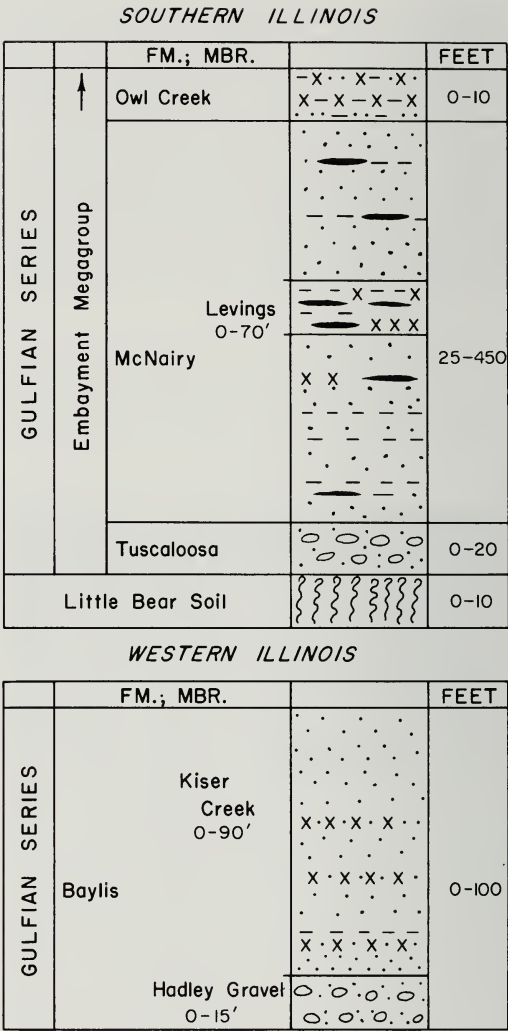


Fig. K-2—Classification of the Cretaceous System.

McNairy Formation

The McNairy Formation (Stephenson, 1914, p. 18, 22) (fig. K-2) is named for McNairy County, Tennessee, where the type section is a railroad cut 1.5 miles west of Cypress Station. It was formerly called a member of the Ripley Formation (Lamar and Sutton, 1930) but was designated a formation by Pryor (1960). The McNairy is widely exposed in extreme southern Illinois, largely south of the Cache River Valley in Massac and Pulaski Counties but also farther west in the southern part of the hills from Olive Branch to Fayetteville in Alexander County (fig. K-1A). The lower part of the formation is widely exposed in roadcuts in the hills 2-4 miles north of Unionville, Massac County (Ross, 1964), and the upper part in the Ohio River bluffs in the vicinity of U.S. Dam 53 in Pulaski County (Pryor and Ross, 1962). The formation is at least 450 feet thick, perhaps locally a little thicker. Along its northern limit it is truncated by the Mounds Gravel.

The McNairy Formation is a deltaic deposit at the northern end of the Mississippi Embayment and consists largely of nonmarine sand deposited by rivers and of lignitic clays and silts deposited in interdistributary areas. The lower part consists of fine, white to light gray, cross-bedded, micaceous sand. A middle section, which is gray to black silt with beds of lignite, is named the Levings Member. The upper part is similar to the lower. In the areas where the McNairy is overlain by the Mounds Gravel, the upper 25-50 feet is commonly stained red by iron oxide. South of Illinois, the McNairy Formation grades into the marine sediments of the Selma Formation.

**Levings Member**—The Levings Member of the McNairy Formation (Pryor and Ross, 1962, p. 19) is named for Levings, Pulaski County, which is 1.5 miles northeast of the type section along a creek southwest of U.S. Dam 53 (NW SW 18, 15S-2E). The Levings Member is largely lignitic silt and clay with thin beds of lignite. It occurs in the middle part of the McNairy Formation, is 0-70 feet thick, and is generally present throughout the northern part of the Mississippi Embayment.

### Owl Creek Formation

The Owl Creek Formation (Hilgard, 1860) (fig. K-2), named for exposures along Owl Creek, 3 miles northeast of Ripley, Tippah County, Mississippi, is the uppermost Cretaceous Formation in southern Illinois. It is exposed in Illinois only in Pulaski County along the Ohio River near U.S. Dam 53 (SE NW NE 13, 15S-1E) and along the Cache River near Unity (NE 7, S1/2 6, 16S-1W) (Pryor and Ross, 1962). It consists of glauconitic, very micaceous, sandy, silty clay and silt 0-10 feet thick. It overlies the McNairy Formation conformably. A weathered zone at its top, marked by concentrations of hematitic nod-

ules and a sharp upper contact, indicates an unconformity that separates the Owl Creek from the overlying Tertiary Clayton Formation. The Owl Creek indicates a brief advance of the sea over the McNairy delta.

### Baylis Formation

The Baylis Formation (Frye et al., 1964, p. 4) (fig. K-2), which comprises all the sediments of Cretaceous age in western Illinois, is named for Baylis, Pike County, 4 miles north of the type section, which is an exposure and small pit along a branch of Kiser Creek (NW SW SE 31, 4S-4W). The Baylis occurs in Pike and Adams Counties in a prominent ridge that extends for about 20 miles northwest of the Pittsfield area, and it also appears 10 miles farther northwest in a smaller, less prominent area south of Mendon in Adams County (fig. K-4). The Baylis has a maximum thickness of about 100 feet near Baylis, but the top of the formation is eroded and it may originally have been much thicker. The Baylis is largely fine to medium quartz sand and clayey sand. In places it contains lenses of silty clay and pebbles of chert, quartz, and quartzite. The basal few feet is generally gravel and is differentiated as the Hadley Gravel Member. The upper, sandy part of the formation is the Kiser Creek Member. The sands are generally white, but in places some beds are stained brown by limonite. The basal part of the gravel is locally strongly cemented with iron and manganese minerals, although most of the formation is uncemented and soft. The Baylis rests unconformably on Mississippian and Pennsylvanian rocks and is overlain unconformably by Pleistocene deposits, generally only loess in the main ridge northwest of Pittsfield but elsewhere by Kansan drift and, locally, by Illinoian drift (fig. K-4). Most

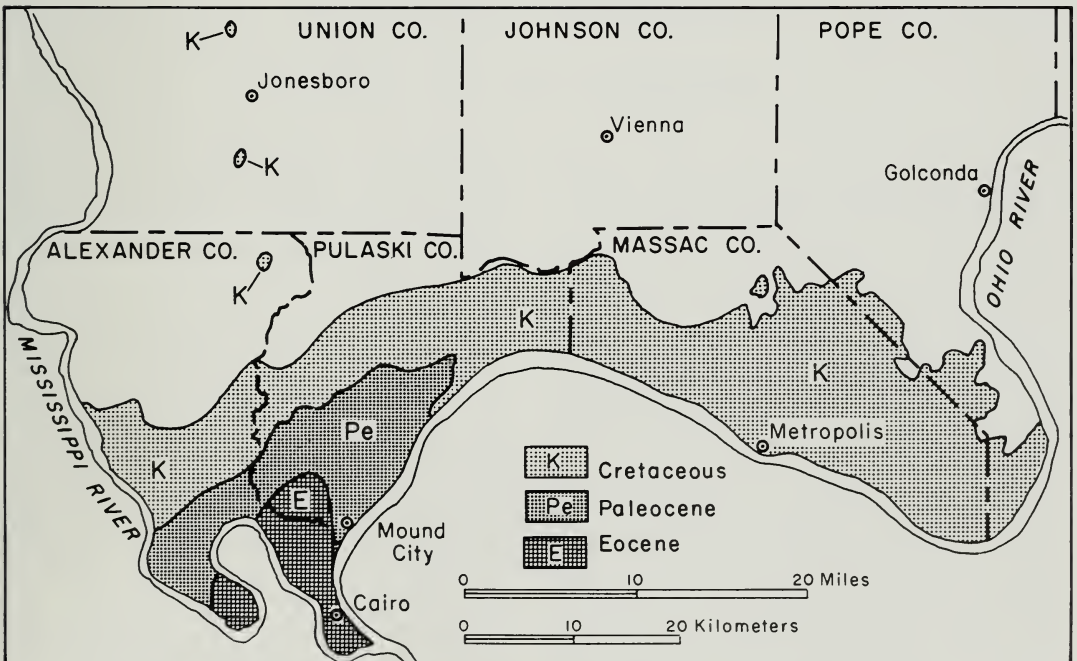


Fig. K-3—Distribution of Cretaceous, Paleocene, and Eocene strata in southern Illinois (after Willman et al., 1967).

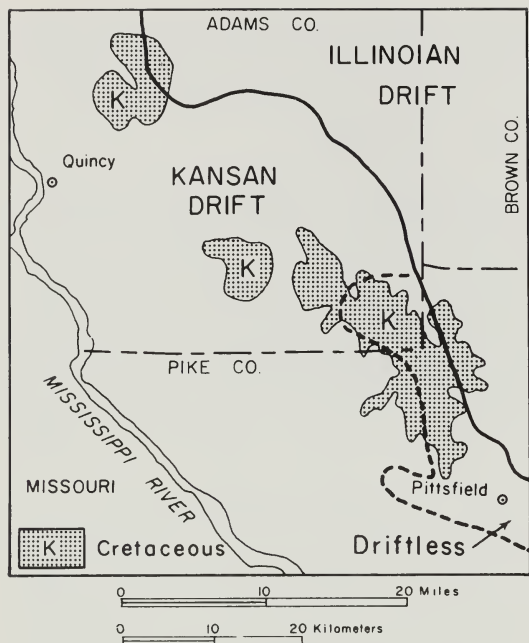


Fig. K-4—Distribution of Cretaceous strata in western Illinois (after Frye et al., 1964).

of the formation is similar in lithology to the Cretaceous Dakota Formation in west-central Iowa, but the Hadley Gravel Member closely resembles the Windrow Formation in Iowa and Wisconsin (Andrews, 1958).

**Hadley Gravel Member**—The Hadley Gravel Member of the Baylis Formation (Frye et al., 1964, p. 4, 8), the basal member, is named for Hadley, Pike County, 4 miles northwest of the type section, which is also the type section for the Baylis Formation. The member is generally present in the outcrop area of the formation. It is as much as 15 feet thick but is generally less than 10 feet and in places is only a layer of pebbles. It is predominantly pebbles and small cobbles of brown, dark gray, and red chert, but 20-30 percent of the pebbles are quartz, and 1-2 percent are quartzite. It differs only slightly from the Grover Gravel of the Tertiary System, which probably was largely reworked from the Cretaceous gravels, but in the Grover Gravel the brown chert pebbles are more abundant, rounder, and more highly polished. Some of the isolated patches of chert gravels long assigned to the Tertiary may be remnants of the Hadley Gravel Member, which originally may have had wide distribution in western and northern Illinois.

**Kiser Creek Member**—The Kiser Creek Member of the Baylis Formation (Frye et al., 1964, p. 4, 10), the upper member, is named for the East Branch of Kiser Creek, a tributary of which exposes the type section, the same section described for the Baylis Formation. The member constitutes the greater part of the formation and is dominantly sand and clayey sand, as described for the formation. The sands and clays of the Kiser Creek Member differ from glacial sands in their uniformity, lack of carbonates, distinctive clay mineral assemblages, and the absence of the variety of heavy minerals that characterizes the glacial deposits.

## CENOZOIC ERATHEM

*H. B. Willman and John C. Frye*

The Cenozoic Eratthem—the strata deposited during the Cenozoic Era (Phillips, 1840)—consists of the Tertiary and Quaternary Systems, which comprise all deposits in Illinois younger than those of the Cretaceous System of Mesozoic age, including those now being deposited. Except for small areas, mainly in western and northern Illinois, rocks of Tertiary age are restricted to extreme southern Illinois (figs. K-1, T-1), whereas deposits of Quaternary age occur throughout the state (fig. 11).

Only a minor unconformity separates the oldest Cenozoic (Tertiary) strata from the youngest Mesozoic (Cretaceous). As the Oligocene and Miocene Series are not present in Illinois, a prominent unconformity separates the oldest Tertiary (Paleocene and Eocene) from the youngest Tertiary (Pliocene) rocks. A major unconformity also separates the Tertiary from the Quaternary. However, because

the Cretaceous and Tertiary Systems are missing in much of Illinois, the Quaternary System, which covers more than 95 percent of the state, lies directly and unconformably on Paleozoic rocks in most places.

The older Tertiary rocks include marine deposits of the Mississippi Embayment, whereas the younger are entirely continental. The Quaternary strata include the glacial deposits that cover 80 percent of Illinois, the loess that mantles nearly all of the state, floodplain alluvium along the rivers and streams, lake and swamp deposits in some lowland areas, sand dunes on terraces and bordering uplands, and the soils that have been developed on most of these deposits.

Many of the Cenozoic rocks are abundantly fossiliferous, and even the oldest have many species nearly like those of the present day. The term Cenozoic means “recent life.”

## TERTIARY SYSTEM

The Tertiary System (Arduino, 1760), a name retained from one of the earliest classifications of rocks, is extensive only in the extreme southern part of Illinois (figs. K-3, T-1), but it also occurs in small widely scattered areas in western and northern Illinois (fig. T-1). Tertiary sediments in southern Illinois are included with Cretaceous sediments in the Embayment Megagroup.

The Paleocene and Eocene Series (fig. T-2) are present as Coastal Plain sediments in extreme southern Illinois, where they are separated from overlapping Pliocene deposits by a major unconformity. Late Eocene, Oligocene, and Miocene sediments are absent, although some sediments of these series could have been deposited and later eroded during development of the sub-Pliocene unconformity. The Jackson Formation of the late Eocene occurs in Kentucky only a short distance south of Illinois, and Oligocene and Miocene deposits occur in the Coastal Plain Embayment area farther south.

Progressive sinking of the embayment area resulted in the relatively rapid southward thickening of the pre-Pliocene Cretaceous and Tertiary deposits and gave them a southward dip significantly greater than that of the Pliocene sediments. Tertiary sediments have a maximum thickness of about 400 feet in the vicinity of Cairo, Alexander County.

The Paleocene sediments are largely marine clays and sands, whereas the Eocene sands and silty clays indicate a return to nonmarine deltaic sedimentation like that operating during the Cretaceous. The Pliocene sediments are mostly fluvial deposits of a continental environment.

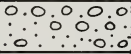

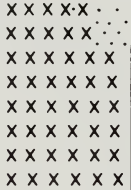
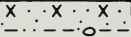
### PALEOCENE SERIES


The Paleocene Series (Schimper, 1874) was differentiated from the Eocene because the floras of the sediments were believed to be sufficiently different from those of the younger Eocene to merit establishing a separate series. The floras of the Paleocene bridge the gap between typical Cretaceous and Eocene floras. Paleocene means "ancient and recent." In Illinois, the Paleocene Series occurs only in the extreme southern counties—Alex-



Fig. T-1—Distribution of the Mounds and Grover Gravels.

ander and Pulaski. Paleocene deposits there have a maximum thickness of about 170 feet and are well exposed along the Ohio River near Olmsted and along the Cache River near Unity. The Paleocene consists of the Clayton (below) and Porters Creek Formations. Both formations include marine clays, but the Clayton is sandy and strongly glauconitic. The clays are dominantly montmorillonite (Pryor and Glass, 1961). Paleocene rocks are fossiliferous, but most of the fossils are microfossils or poorly preserved macrofossils. The heavy minerals in the Paleocene sediments are similar to those in the Cretaceous and indicate their source was the metamorphic rocks of the

SOUTHERN ILLINOIS			
SER.	FORMATION		FEET
P-P*	Mounds Gravel		0-50
EOCENE	Wilcox		0-250
PALEOCENE	Porters Creek		50-150
	Clayton		15-20

WESTERN AND NORTHERN ILLINOIS			
SER.	FORMATION		FEET
P-P	Grover Gravel		0-10

\*P - P = Pliocene - Pleistocene

Fig. T-2—Classification of the Tertiary System.

Piedmont region far to the east. South of Illinois, the two formations are classified as the Midway Group.

Clayton Formation

The Clayton Formation (Landon, 1891, p. 594) (fig. T-2), named for exposures near Clayton, Barbour County, Alabama, is persistently present at the base of the Paleocene Series in southern Illinois (Pryor and Ross, 1962). It is well exposed in a small ravine northwest of U.S. Dam 53 in Pulaski County (SE NW NE 13, 15S-1E). It is commonly 15-20 feet thick and consists of glauconitic, micaceous, green to buff silty clay that is sandy and pebbly at the base. Foraminifera are the main fossils in the Clayton Formation, but the remains of radiolarians and other plankton also are present. The Clayton is generally less sandy and more glauconitic than the Owl Creek Formation below, and the contact, which is unconformable, is marked by pebbles of white and black chert and iron oxide in the base of the Clayton.

Porters Creek Formation

The Porters Creek Formation (Stafford, 1864, p. 361, 368) (fig. T-2) is named for exposures on Porters Creek in Hardeman County, Tennessee. It is present in Alexander and Pulaski Counties in southern Illinois (Lamar, 1928b; Pryor and Ross, 1962) and is well exposed in pits south of Olmsted, Pulaski County (NE SE 27, 15S-1E), in the Ohio River bluffs near U.S. Dam 53, and along

the Cache River near Unity. It is 50-150 feet thick, but north of the Cache Valley it is completely truncated by the Mounds Gravel. The Porters Creek is largely massive, compact, essentially unbedded or weakly bedded, dark gray to nearly black clay that has a blocky fracture. It is gray-tan to white where weathered. Because it does not readily become plastic when wet, it can stand in steeper faces than most clays. It is more than 80 percent montmorillonite. Microfossils (Radiolaria, Hystrichospheridae, and Foraminifera) are abundant, but fish scales, shark teeth, and casts and molds of pelecypods and gastropods are also common. The Porters Creek is overlain unconformably by the Wilcox Formation, which locally cuts deeply into the Porters Creek. The Porters Creek is a marine deposit representing an advance of the sea over essentially the entire area of the embayment. Because the clay has the absorptive and filtering properties of fuller's earth, it has been mined commercially south of Olmsted, Pulaski County.

EOCENE SERIES

The Eocene Series (Lyell, 1833) in Illinois occurs in a small area in Pulaski and Alexander Counties. It is exposed only in Pulaski County in the hills from Mounds west to Cache Valley. The Eocene sediments are all assigned to the Wilcox Formation. The Eocene, which means "dawn of the recent," was so named because its flora and fauna contained only a small proportion of recent species.

Wilcox Formation

The Wilcox Formation (Crider and Johnson, 1906, p. 5, 9) (fig. T-2) is named for Wilcox County, Alabama. It was formerly called Lagrange in Illinois (Lamar and Sutton, 1930). It is exposed in Illinois only in Pulaski County (Pryor and Ross, 1962), along the east side of the Cache River south of Unity, particularly in a pit where 20 feet of sand of the Wilcox Formation overlies the Porters Creek Formation and is overlain by the Mounds Gravel (SE SW SW 7, 16S-1W) (Pryor and Ross, 1962). The Wilcox varies from white, fine to medium, slightly micaceous sand to gray, nearly white, silty or sandy clay. It is only 20-30 feet thick in the outcrop area, but it thickens southward and is as much as 250 feet thick in subsurface near Cairo, Alexander County. The Wilcox was deposited in a delta at the head of the embayment. It probably is equivalent to only part of the Wilcox farther south in Kentucky and Tennessee.

PLIOCENE SERIES

The Pliocene Series (Lyell, 1833), translated as "more recent," was so named because the major part of the invertebrate fossils are

referable to modern species. It is represented in Illinois by the widespread brown chert gravel deposits of southern Illinois—the Mounds Gravel—and the similar but scattered deposits in western Illinois—the Grover Gravel. All of these deposits were previously called “Lafayette,” “Lafayette-type,” or “Tertiary” gravel. Both formations probably contain some deposits reworked during the early Pleistocene that are not readily differentiated from those deposited during the late Tertiary. Consequently, both the Mounds and Grover Formations are assigned a Pliocene-Pleistocene age (Willman and Frye, 1970).

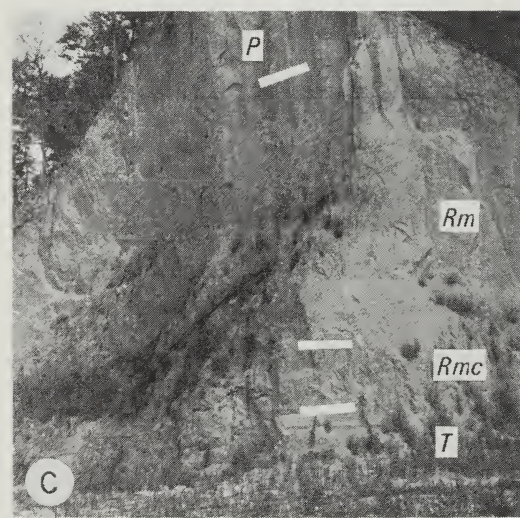
### *Mounds Gravel*

The Mounds Gravel (Willman and Frye, 1970, p. 20) (fig. T-2) is named for Mounds, Pulaski County, which is 3 miles east of the type section in a gravel pit on the east side of Cache Valley (SE SW SW 7, 16S-1W). The formation is widely present and is exposed in numerous gravel pits and roadcuts in the area south of Cache Valley and westward from Cache Valley to the Mississippi River (fig. T-1). Good exposures also occur in pits in the hills 8 miles northeast of Metropolis, Massac County (SW SW 28, 14S-5E) (fig. K-1B). An isolated remnant of the gravel lies on top of the Shawneetown Hills in Gallatin County. The gravel is found in three terraces, the upper at an elevation of 580-620 feet, a middle terrace at 450-500 feet, and a lower terrace at 380-400 feet. The gravel underlying these surfaces is rarely as much as 40 feet thick, more commonly less than 20 feet. It is dominantly medium to dark brown chert pebbles with a glossy surface in a matrix of coarse red sand, but in places it is largely pebbly sand. Most of the pebbles are partly rounded and many are well rounded (fig. K-1C). Many of the chert pebbles are 2-3 inches in diameter, or even larger, in places. Quartz pebbles, also well rounded, are common and are generally less than half an inch in diameter. The lithology of the gravel has been well described by Lamar and Reynolds (1951) and Potter (1955). Cross-bedding and heavy-mineral content indicate that the Mounds Gravel in southern Illinois was largely deposited by streams flowing from the east or southeast, probably down the Tennessee River Valley on the east side of the embayment area. However, the deposits near the Mississippi River at the head of the embayment and on its west side contain chert, agate, and purple quartzite pebbles characteristic of the Lake Superior region, which indicates some contribution from the north. The Mounds Gravel truncates the older Tertiary and Cretaceous sediments. It, in turn, was deeply dissected and weathered before the oldest Pleistocene deposit in the area, the Illinoian Loveland Silt, was deposited on it. The rivers and streams have entrenched themselves at least 300 feet since the earliest of the gravels was deposited on the highest bedrock surfaces. Although the highest deposits are believed to be Pliocene in age, similar deposits on the

lowest surfaces may have been reworked from the higher levels during the early part of the Pleistocene. The Mounds Gravel does not contain the igneous and carbonate rocks or the heavy minerals characteristic of the glacial deposits of the Upper Mississippi and Ohio River Valleys, but such materials would not be found in sediments from the upper Tennessee River Valley. The age of the gravels is controversial (Fisk, 1944; Leighton and Willman, 1950; Potter, 1955; Willman and Frye, 1970), and the Mounds Gravel is therefore now classified as Pliocene-Pleistocene.

### *Grover Gravel*

The Grover Gravel (Rubey, 1952, p. 61) (fig. T-2) is named for Grover, St. Louis County, Missouri, near which it is well exposed on the highest upland surface as overburden in several clay pits (SE NW SW 3, 44N-3E). The formation is as much as 50 feet thick in the type area. It also occurs widely, however, as small relict patches of chert gravel or scattered pebbles at the base of the loess on the upland surface of Calhoun County, Illinois. Isolated patches of similar chert gravel also are found in western and northern Illinois (fig. T-1). The gravel is mainly rounded, brown chert pebbles with some red hematitic chert, purple quartzite, and white and pink quartz pebbles. The matrix is largely red to tan quartz sand, the heavy minerals in which are dominantly zircon and tourmaline. Boulders of purple and pink quartzite as much as 2 feet in diameter occur in the Grover area and in one locality near Golden Eagle, Calhoun County (NE NE SE 36, 13S-2W). The isolated gravel patches included in the Grover Formation (Horberg, 1950b) because of their stratigraphic position on the bedrock in the uplands and beneath Pleistocene deposits of glacial drift or loess are probably not all of the same age. Some may be remnants of Cretaceous gravel, others of Tertiary gravel that perhaps was reworked from the Cretaceous gravel, and still others may have been reworked from the Tertiary gravel in early Pleistocene time. A few deposits contain rare pebbles of igneous and metamorphic rocks, reduced by weathering to clay with coarse mica flakes (Leighton and Willman, 1949), and these most likely are Pleistocene in age. Although the Mounds Gravel near the Mississippi River in southern Illinois contains some materials from the Upper Mississippi River Valley, similar gravel has not been found between the St. Louis area and the southern Illinois area. The connecting valley apparently has been eroded, probably as a result of uplift of the Ozark Dome. The Grover Gravel has long been interpreted as Tertiary, generally Pliocene, in age (Salisbury, 1892). Rubey (1952) considered the gravel to be as old as Miocene because of the amount of erosion that had taken place after it was deposited and because the gravel appears to be displaced more than 100 feet by movement along the Cap au Grès Faulted Flexure in Calhoun County. Because of the large quartzite boulders in the gravel, Willman and Frye (1958, 1970) suggested that the gravel may be early Pleistocene. As definitive faunal evidence is unavailable, the Grover Gravel is classified as Pliocene-Pleistocene in age.



## QUATERNARY SYSTEM

*John C. Frye and H. B. Willman*

The Quaternary System was proposed in 1829 by Desnoyers (Wilmarth, 1925, p. 43), who recognized it as a unit distinct from the Tertiary System. Its definition depends on the placement of the end of Tertiary time. The Pleistocene Series also began at that time, and in Illinois classification the Quaternary System is equivalent to that one series. In 1925 the Pleistocene was classified as a system in Illinois, and the term "Quaternary" was not used until 1950 when the Pleistocene was reduced to a series and the Quaternary reinstated as a system. The Quaternary System includes the rocks being deposited at present.

### PLEISTOCENE SERIES

The term "Pleistocene" was introduced by Lyell in 1839 (p. 616-621) as a replacement for "Newer Pliocene" (Lyell, 1833, p. 52-53) to apply to the marine strata of the Mediterranean region, in which more than 70 percent of the fossils represent living species. In 1846 Forbes applied "Pleistocene" to the "glacial epoch" in the British Isles, and in 1925 Wilmarth defined the Pleistocene in North America as including glacial and contemporaneous deposits of the "Great Ice Age." A report to the International Geological Congress in 1952 suggested worldwide adoption of a definition of the base of the Pleistocene as the base of the Villafranchian or of the equivalent marine Calabrian as exposed in Italy. However, as correlations of this proposed type area with marine strata in North America are not firmly established, the Pleistocene Series in Illinois and the rest of

the continental interior continues to be defined as the glacial sequence plus the contemporaneous deposits laid down beyond the limit of continental glaciation. The Pleistocene Series includes the Holocene (Recent), which is classified as a stage rather than as a separate series, the usage accepted by many others.

Deposits of Pleistocene age are the surficial materials in virtually all of Illinois (fig. Q-1). Nearly 80 percent of the state was covered at least once by continental glaciers that left characteristic deposits (drift). Both glaciated and unglaciated areas were largely covered by wind-deposited silt (loess), by lacustrine deposits, or by deposits from streams. The only areas that were not covered by glaciers are the extreme northwestern corner, the southernmost part, and relatively small areas along the western border (fig. Q-2).

The thickness of the Pleistocene deposits in Illinois ranges from zero to approximately 600 feet (fig. Q-3), and variations in thickness occur sharply in relatively small areas. The drift is thick where major valleys in the older rocks have been filled by Pleistocene deposits and where stillstands of a glacier front have built thick ridges (moraines) of glacial debris. Drift thicknesses are greatest where glacial moraines cross the filled valleys. The loess deposits, which were derived largely from glacial outwash in the major valleys by the action of winds, are thickest along the margins of those valleys and thin rapidly away from them, in some places thinning from as much as 100 feet to less than 20 feet thick in a distance of 10 miles. Loess disappears en-

Fig. Q-1—Exposures of Pleistocene deposits.

- A—Wisconsinan Richland Loess (R), Delavan Till Member of the Wedron Formation (Wd), Morton Loess (M), Robein and Roxana Silts (RR), and the Sangamon Soil (S) on till of the Illinoian Glasford Formation (C); in a railroad cut a mile east of Farmdale, Tazewell County, near the classic Farm Creek Section (Willman and Frye, 1970, p. 183).
- B—The Wisconsinan Wedron (W—interbedded till and outwash) and Peddicord (P—lake sediments) Formations overlying till of the Illinoian Glasford Formation in the Wedron Silica Company pit at Wedron, La Salle County—the type sections of the Wedron and Peddicord Formations (Willman and Payne, 1942, p. 148; Willman and Frye, 1970, p. 190; Willman et al., 1971).
- C—Wisconsinan Peoria Loess (P) overlying the Roxana Silt (Rm—Meadow Loess Member, Rmc—McDonough Loess Member) and the Illinoian Teneriffe Silt (T) in the Pleasant Grove School Section in the Mississippi River bluffs northwest of Collinsville, Madison County (Willman and Frye, 1970, p. 187).
- D—Illinoian Glasford Formation (Hagarstown Member) showing steeply dipping sand and gravel (crevasse deposit) in a mound in the Kaskaskia Ridged Drift area, 2 miles southwest of Lakewood, Shelby County.
- E—Wisconsinan Roxana Silt (R), Sangamon Soil developed in the Illinoian Loveland Silt (SL) and Yarmouth Soil developed in till of the Kansan Banner Formation (YB); in a roadcut at Independence, 5 miles south of Pittsfield, Pike County (Frye et al., 1964, p. 27).
- F—Harkness Silt Member of the Kansan Banner Formation (Bh) overlying the Afton Soil developed on gravel of the Nebraskan Enion Formation (AE); in a roadcut at the Zion Church, 2 miles southeast of Marblehead, Adams County (Willman and Frye, 1970, p. 191).

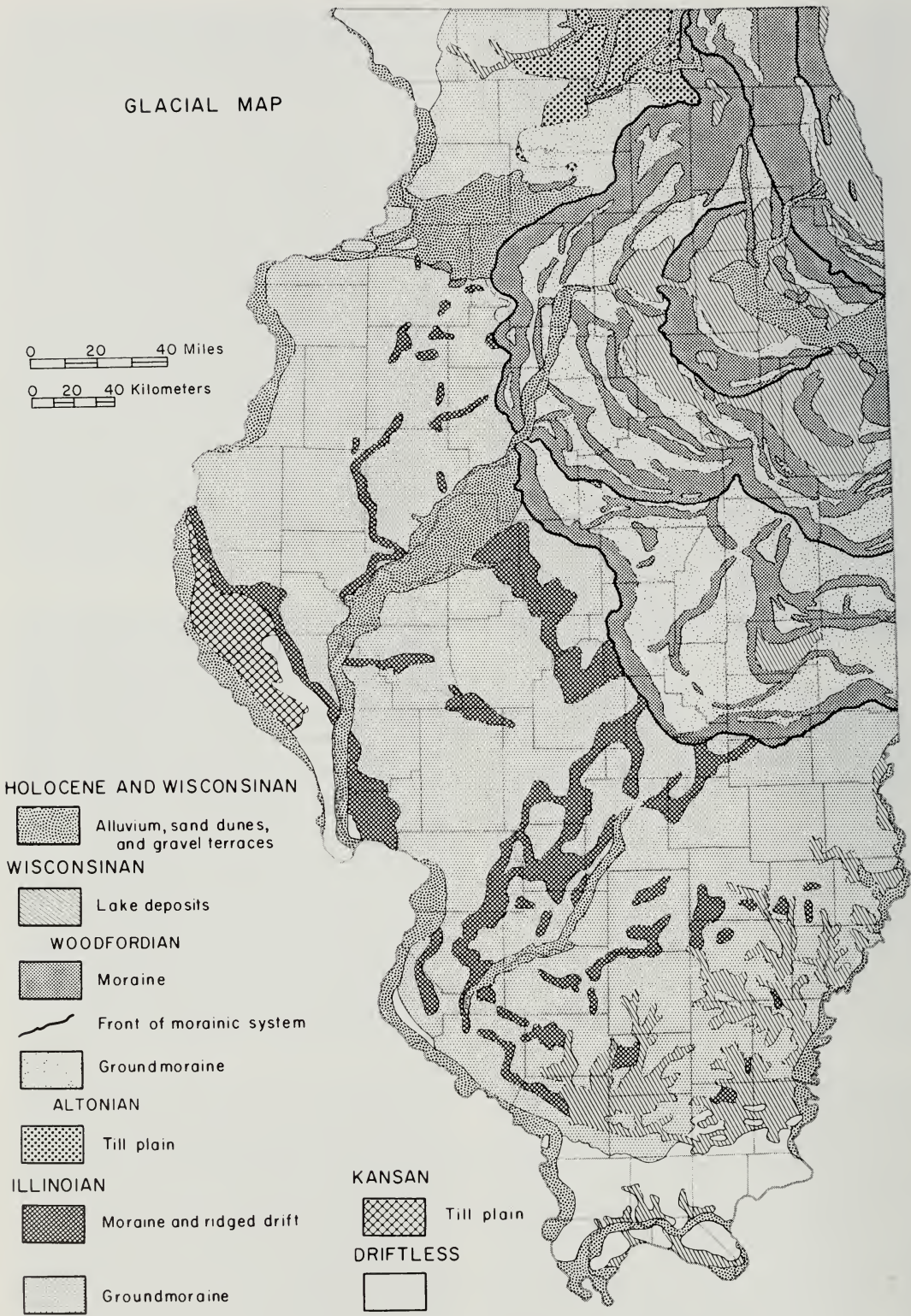


Fig. Q-2—Glacial map of Illinois (after Willman and Frye, 1970).

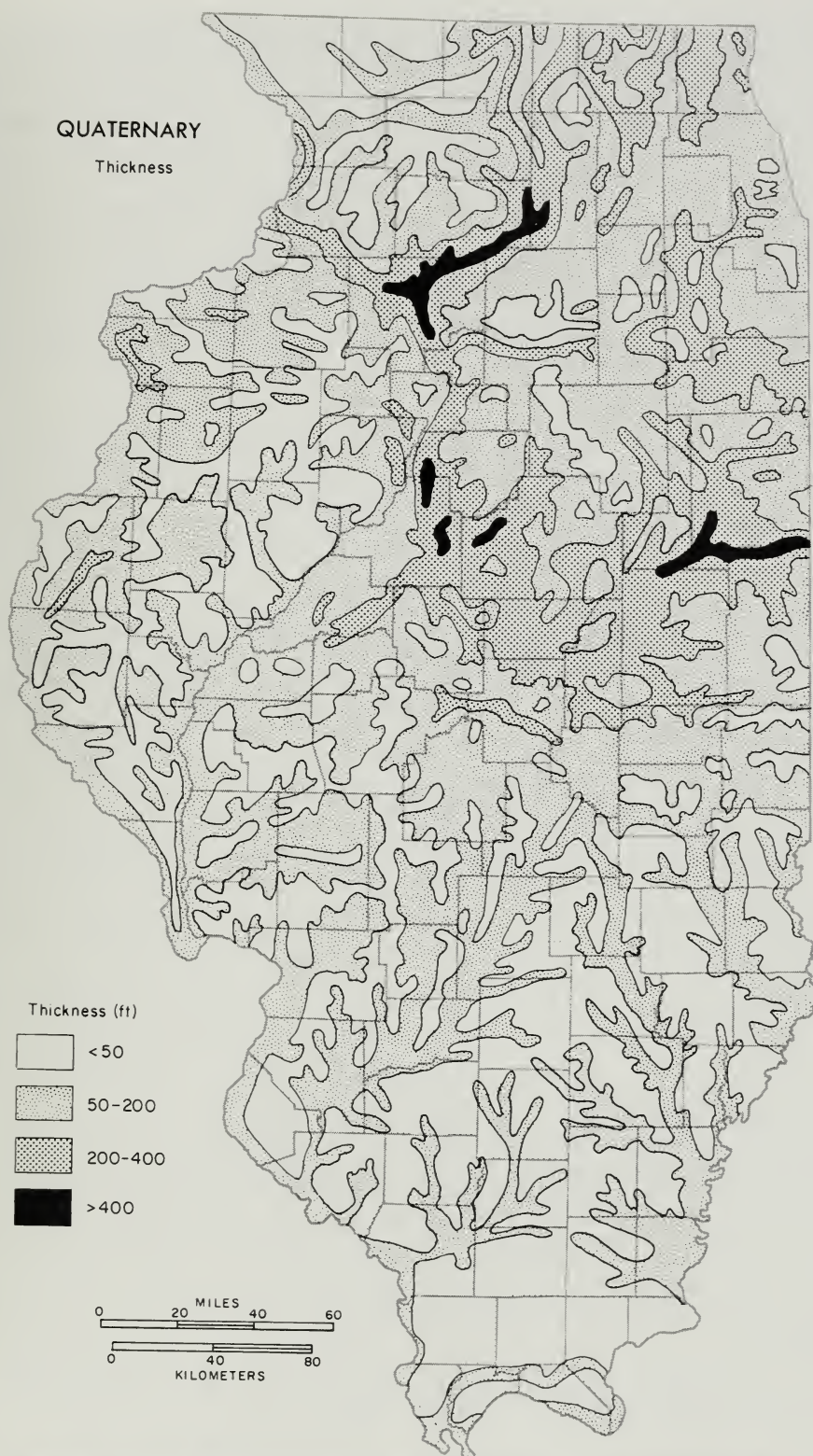


Fig. Q-3—Generalized thickness of the Quaternary deposits of Illinois (after Piskin and Bergstrom, 1967; Willman and Frye, 1970).

tirely on the surfaces of alluvial valleys and some of the lake plains. Dune sands vary abruptly in thickness and do not display the regular, linear pattern of the loess deposits.

The Pleistocene deposits in Illinois also have a wide range in lithology—bouldery glacial tills, well sorted silts, accretion-ogley, and fine-grained lacustrine clays. Glacial tills strongly reflect their mode of origin and their source areas. Glacial regimen changes with the temperature and thickness of the ice, the rate of ice flow, and the manner in which the ice disappeared. In some areas excess of marginal melting over forward motion caused retreat of the ice front. In other areas the ice lost forward motion, stagnated, and melted down from the top. All of these factors influence the resulting deposit. Glacial tills range from dominantly sand and gravel with only a small fraction of clay and silt and a few small boulders to mixtures dominantly clay or silt, with some sand, pebbles, and dispersed boulders.

Alluvial deposits are the product of normal stream action, of meltwaters in, on, or below glacial ice, or of meltwaters flowing from glaciers to a considerable distance (outwash). These deposits range from coarse, bouldery gravel to sand and silt.

Eolian deposits of loess and dune sand result from the action of winds on exposed surfaces of nonindurated materials, mostly glacial outwash. Eolian sediments are well sorted, consisting largely of medium-grained sand in the dunes and coarse to fine silt in the loess deposits. Loess deposits progressively thin and become finer grained away from their source areas in the major valleys. They range from coarse silt containing fine sand immediately adjacent to their source to fine silt containing significant amounts of clay in remote areas.

During Pleistocene time lakes formed along glacial fronts, between morainic ridges, in valleys dammed by glaciers, and in tributary valleys blocked by rapidly alluviating master streams that were receiving large quantities of outwash. The lacustrine deposits are predominantly well bedded silt, clay, and fine to medium sand. Although most lacustrine sediments are largely silt, some are predominantly sand, and others are interbedded silt, sand, and clay.

Colluvium and gravity deposits are produced by the influence of gravity on slopes. The materials in such deposits strongly reflect the local source from which they were derived, which is always up-slope from the de-

posit. The two categories are differentiated largely by rate of transport and particle size. Colluvial deposits move slowly down-slope, commonly contain a significant percentage of silt, clay, and some coarser fragments, and may or may not have a well defined slip plane separating them from the older rocks below. Gravity deposits are generally composed of angular fragments, are more poorly sorted, are coarser, and are associated with steeper slopes than colluvium. They include talus deposits. Both colluvium and gravity deposits are poorly sorted unless the source material is a uniform and well sorted sediment, such as loess.

Man-made deposits are extensively exposed at the surface in strip-mined areas, filled areas, and artificially created islands. Sanitary landfills also are man-made surficial deposits. Such deposits have no predictable lithology and range from refuse and stripped overburden of mines to relatively uniform sand or silt.

The mineral composition of Pleistocene deposits strongly reflects the source areas of the sediments. Source areas of colluvial and gravity deposits are close at hand, but glacial deposits reflect sources hundreds of miles away. Glacial till contains rocks and minerals picked up by the ice as the glaciers advanced; the heavy minerals of the sands were commonly derived from the crystalline rocks of southern Canada and the clay minerals and carbonates from the Paleozoic rocks farther south. The mineral compositions of the older rocks vary widely from east to west, and, consequently, the direction of ice flow and the correlation of many units can be determined by mineral analysis of the tills. As the sediments of the outwash were derived largely from the glacially transported material, their mineral composition and that of the eolian deposits derived from them also reflect the sources of the glacial deposits.

The tills from a northwestern source (Keewatin Lobe) are characterized by high montmorillonite content, more calcite than dolomite, and more epidote than garnet. Tills from the north and northeast (Lake Michigan Lobe) have a high illite content, much more dolomite than calcite, and nearly equal amounts of garnet and epidote. Tills from farther east (Saginaw, Huron, Erie Lobes) have a high illite content, generally more calcite than dolomite, and much more garnet than epidote.

Pleistocene deposits in Illinois are classified in four basic hierarchies—time-stratigraphic,

rock-stratigraphic, soil-stratigraphic, and morphostratigraphic. Time-stratigraphic and rock-stratigraphic classifications are used for Pleistocene deposits in the same manner they are used in the rest of the stratigraphic sequence (fig. 16) and will not be redescribed here. The chart in figure Q-4 shows all time-stratigraphic, rock-stratigraphic, and soil-stratigraphic terms currently in use in Illinois and this report. The surface distribution of the dominantly till formations and members is shown in figure Q-5. Figure Q-6 shows graphically the historical development of the time-stratigraphic classification of the Wisconsin Stage in Illinois.

Soil-stratigraphic and morphostratigraphic units are virtually unique to the Pleistocene. Soils form at the land surface as a result of the effects of weathering and of plants and animals on the sediments that underlie the surface. In most places soil forms in situ, that is, by the progressive downward alteration of sediments below a relatively stable surface. In some places, however, soils have formed by slow accumulation of fine sediment on the surface, with or without organic material. Soils buried by younger sediments are part of the stratigraphic sequence. Soil-stratigraphic classification, consisting of only one rank

TIME STRATIGRAPHY				ROCK STRATIGRAPHY										SOIL STRATIGRAPHY		
QUATERNARY SYSTEM	PLEISTOCENE SERIES	WISCONSINAN STAGE	HOLOCENE STAGE													Modern Soil
			VALDERAN SUBSTAGE	Peoria Loess	Richland Loess	Lake Michigan Fm.	Ravinia Sand M.									
			TWOCREEKAN SUBSTAGE				Waukegan M.									
			WOODFORDIAN SUBSTAGE				Lake Forest M.									
						Winnetka M.										
					Sheboygan M.											
					Wilmette B.											
					South Haven M.											

Fm.=Formation M.=Member T.M.=Till Member B.=Bed

Fig. Q-4—Classification of the Pleistocene Series.



Fig. Q-5—Areal distribution of the dominantly till formations and members of Illinois (after Willman and Frye, 1970; Johnson et al., 1972).

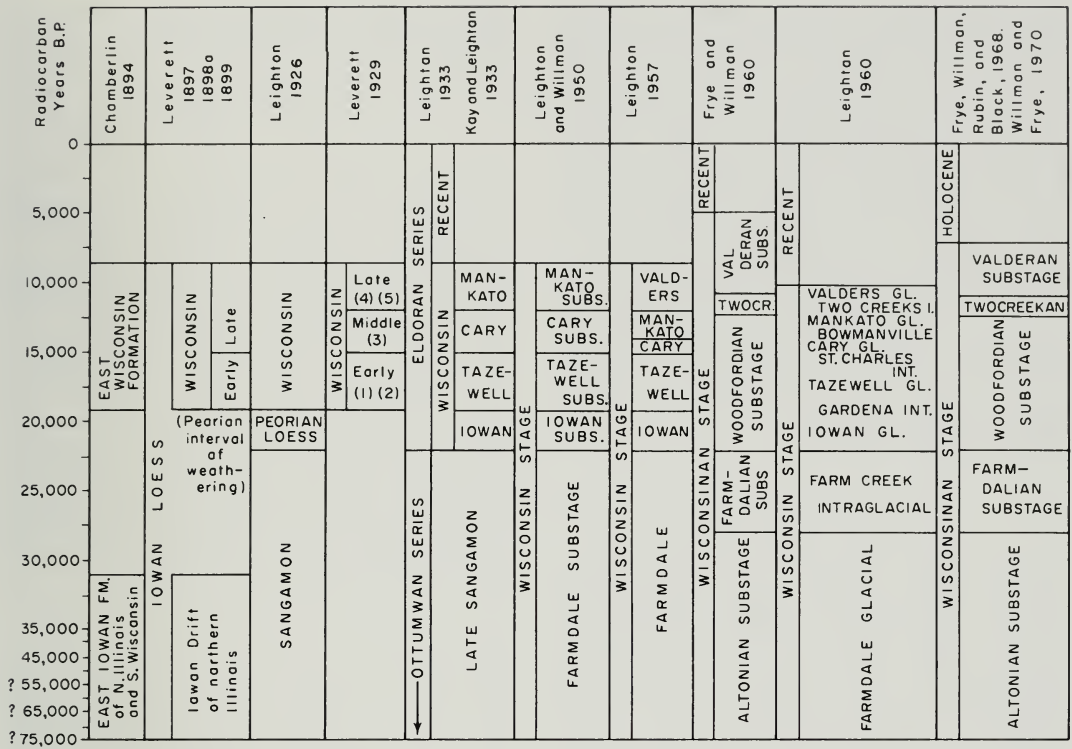


Fig. Q-6—Development of the classification of the Wisconsin Stage in Illinois.

(soil), is a means of naming, describing, and correlating the soils in the sediment sequence. Soils do not replace the rock-stratigraphic units they are developed on; commonly, each soil is developed on several units. Only the upper surface of a soil presents a definable stratigraphic plane, because the lower part of a soil is gradational. The physical and mineral characteristics of a soil profile are generally useful in its recognition and correlation.

Morphostratigraphic units, as the name implies, are bodies of rock that are recognized and named on the basis of their surface form. Glacially produced morainic ridges, the materials in which are called drifts, and dissected alluviated surfaces, called alluvial terraces, are the two types of morphostratigraphic units recognized in Illinois. Only the drifts are formally named. Drifts are recognized not only in the surface areas but also wherever they can be identified in buried sequences. Such units are particularly useful in classification and mapping of glacial deposits in areas where a single rock-stratigraphic unit, such as glacial till, includes several morainic ridges.

The stratigraphic relations of Pleistocene deposits in Illinois are complex and contrast sharply with the more regular and uniform succession of predominantly marine Paleozoic rocks that they overlie. The complexity is caused by the different modes of deposition, the multiple sources of sediment, and the lack of regional continuity of many of the stratigraphic units. The loesses and the soil-stratigraphic units have the greatest regional continuity, although some of the glacial till units are traceable for more than 100 miles. Outwash and alluvial deposits, in general, occur along present and buried valleys, lacustrine deposits are found along segments of ponded valleys and on low areas of the till plain surfaces, and colluvium and gravity deposits are restricted to localized areas along valley margins. An idealized representation of stratigraphic relations of deposits of the Illinoian Stage in west-central and western Illinois is shown by figure Q-7, and another of Wisconsinan deposits from northeastern to west-central Illinois by figure Q-8.

Fossils are not abundant in most of the Pleistocene deposits of Illinois. None have

thus far been found in the Nebraskan Stage, and assemblages of fossil mollusks have been collected and described from less than a dozen localities of the Kansan Stage. Several silt units of the Illinoian Stage contain relatively abundant assemblages of fossil mollusks at localities in the central and western parts of the state. The Wisconsinan and Holocene Stages contain abundant assemblages of both aquatic and terrestrial mollusks. Fossil vertebrates have also been collected from Pleistocene deposits at many localities. Although the remains of large proboscidiens, such as mammoths and mastodons, have attracted the most attention, remains of smaller mammals, particularly rodents, have been recovered from several localities.

### Nebraskan Stage

The name "Nebraskan" was proposed by Shimek (1909, p. 408) for the lowermost till at the Afton Junction-Thayer exposures in Union County, Iowa, based on its supposed extension into eastern Nebraska. Willman and Frye (1970, p. 118) proposed two reference sections for Illinois, the Zion Church Section in Adams County, and the Enion Section in Fulton County. The base of the Nebraskan Stage is defined by the contact of glacial or glacial-derived deposits with Tertiary or older deposits below, and its upper limit is the top of the in-situ Afton Soil that developed on the Nebraskan deposits (fig. Q-4). The Nebraskan Stage contains the deposits left by the first episode of continental glaciation in the Midwest. The deposits in western Illinois are genetically related to a glacial advance that crossed Iowa from the Keewatin center west of Hudson Bay in Canada. No Nebraskan-age glacial deposits from a northeastern center have been identified with certainty in Illinois. The Enion Formation contains deposits of Nebraskan age, and the Mounds Gravel of southern Illinois and the Grover Gravel of western and northern Illinois, described in the discussion of the Tertiary System, may be, in part, of Nebraskan age.

### Enion Formation

The Enion Formation (Willman and Frye, 1970, p. 48) is named for Enion, Fulton County, half a mile east of the type section (NW SW SE 32, 4N-3E). The formation includes glacial till, outwash sand and gravel, and beds of silt that occur in both the uppermost part and at the base. It is exposed at only a few places, mostly in the west-central part of the state (fig. Q-1F). It differs from older Cretaceous and Tertiary deposits in that it contains crys-

talline rocks from the Canadian area and a heavy mineral suite that includes abundant ferromagnesian minerals.

### Aftonian Stage

The Aftonian Stage (Chamberlin, 1894) is named for Afton Junction, Iowa, where Chamberlin interpreted deposits in a gravel pit as being interglacial. During subsequent years, usage transferred the name to accretion-gley deposits and to the deeply developed in-situ Afton Soil on the Nebraskan-age till of southern Iowa. Although there is now reasonable doubt concerning the age of Chamberlin's type gravels near Afton Junction, the name Aftonian has been retained because of its long-accepted use. The time span of the Aftonian is defined as the time of development of the in-situ Afton soil profile, and a reference section for Illinois has been designated as the Zion Church Section of Adams County (Willman and Frye, 1970).

### Afton Soil

The name "Afton Soil" was proposed by Frye and Leonard (1952, p. 24, 68) for the soil on deposits of Nebraskan age in northeastern Kansas because of its presumed Aftonian age. They designated the Iowa Point Section in Doniphan County, Kansas, as a reference section, and Willman and Frye (1970, p. 82) suggested the Zion Church Section, Adams County (fig. Q-1F), as a reference for Illinois. It is a deeply developed in-situ soil profile in deposits of Nebraskan age, but it has been correlated with accretion-gley, or accretionary soils, on the Nebraskan till plain and with soils developed in older rocks that are overlain by deposits of Kansan age. It has been identified at only a few places in Illinois.

### Kansan Stage

The name "Kansan" was proposed by Chamberlin (1894, p. 754), but the drift was assigned to its present stratigraphic position by Calvin (1897) and Bain (1897) because of the continuity of the deposits described by Chamberlin in Union County, Iowa, with the surface drift in northeastern Kansas. Frye and Leonard (1952, p. 74) proposed three reference sections for type Kansan in Atchison and Doniphan Counties, Kansas, and included within the stage both the proglacial sands below the till (Atchison Formation) and the retreating outwash gravels above the till, in which the Yarmouth Soil is developed. It was defined as including the span of rocks between the top of the Afton Soil (below) and the top of the in-situ Yarmouth Soil (above). Willman and Frye (1970, p. 119) suggested as reference sections for Illinois the Enion

Section of Fulton County, the Tindall School Section of Peoria County, and the Zion Church Section of Adams County. All the deposits of Kansan age found in Illinois are in the Banner Formation.

## **Banner Formation**

The Banner Formation (Willman and Frye, 1970, p. 48) is named for Banner, Peoria County, near which the type section is in the Tindall School Section (SW SW NE 31, 7N-6E). It includes the glacial tills and underlying and intercalated sands, gravels, and silts overlying the Afton Soil and is terminated at the top by the top of the Yarmouth Soil (fig. Q-1E, F). In a few places the formation is as much as 300 feet thick, but it is discontinuous. In west-central Illinois it was deposited by glaciers from the northwest, but in eastern Illinois it was deposited by glaciers from the northeast. Its mineral content reflects the contrasting source areas, and in both regions its mineral content helps to distinguish it from the overlying deposits of Illinoian age. The uppermost part locally contains deposits of clay and silt that accumulated on the till plain surface as accretion-gley, in part during Yarmouthian time, but elsewhere the top of the formation is marked by the in-situ Yarmouth Soil developed in Kansan age deposits. Nine members are recognized in the Banner Formation (fig. Q-4), which is the surface drift in part of western Illinois (fig. Q-5).

**Sankoty Sand Member**—The Sankoty Sand Member of the Banner Formation (Horberg, 1950a, p. 34) is named for the Sankoty water-well field along the Illinois River on the north side of Peoria, Peoria County, where the type section is in a well (NW SE 15, 9N-8E). It is well sorted, medium- and coarse-grained sand, distinguished by an abundance of highly polished pink quartz grains. It occurs above Paleozoic rocks in the deepest part of the Ancient Mississippi Valley, where it is commonly 100 feet thick but locally is as much as 300 feet thick. It is overlain by tills of the Banner Formation except where they have been removed by erosion. It occurs in central and northwestern Illinois.

**Mahomet Sand Member**—The Mahomet Sand Member of the Banner Formation (Horberg, 1953, p. 18, 19) is named for Mahomet, Champaign County, near which it is encountered in numerous wells. The Mahomet Sand Member consists of sand and gravel with many silt beds. It lacks the pink quartz grains that occur in the Sankoty Sand. It occupies the deeper parts of the filled Mahomet Valley and its tributaries, mainly in De Witt, Macon, Piatt, and Champaign Counties. It commonly rests on Paleozoic rocks, attains a maximum thickness of 150 feet, and is overlain by till of the Banner Formation.

**Harkness Silt Member**—The Harkness Silt Member of the Banner Formation (Willman and Frye, 1970, p. 51) is named for Harkness Creek, Adams County, near which the type section is in the Zion Church Section (SE SE SW 9, 3S-8W) (fig. Q-1F). It consists of massive, calcareous, gray and tan silt that contains sparse molluscan fossils. It rests on the Afton Soil and is overlain by glacial till that also is of Kansan age. The member is generally less than 10 feet thick and is exposed at only a few places in central western Illinois.

**Hegeler Till Member**—The Hegeler Till Member of the Banner Formation (Johnson, 1971, p. 8) is named for the town of Hegeler, Vermilion County, and the type section is in the Harmattan Strip Mine No. 2 (SE SW SW 34, 20N-12W). The unit consists of two zones; the lower is outwash with gravelly till and the upper is silty till. It is up to 8 feet thick,

greenish gray, weakly calcareous, generally massive, and compact. It is known in only the one locality, where it rests on rocks of Pennsylvanian age and is overlain by the Belgium Member.

**Belgium Member**—The Belgium Member of the Banner Formation (Johnson, 1971, p. 10) is named for the town of Belgium, Vermilion County, and the type section is in the same exposure as the Hegeler Till Member. The Belgium Member consists of two units; the lower is massive, tan to dark gray-brown, carbonaceous, calcareous, fossiliferous silt 0.5-2.5 feet thick (Leonard et al., 1971), and the upper is brown calcareous clay 0.5-1.5 feet thick. The Belgium Member is bounded below by the Hegeler Till Member or bedrock and above by the Harmattan Till Member. It is known in only the one locality in central eastern Illinois.

**Harmattan Till Member**—The Harmattan Till Member of the Banner Formation (Johnson et al., 1971, p. 194) is named for the Harmattan Strip Mine near Danville, Vermilion County (NE 4, 19N-12W). The member is largely gray, calcareous, dense, hard till, but the upper part contains lenticular bodies of gravelly sand. It is bounded at the base by the Belgium Member, or bedrock, and at the top by the Hillery Till Member. In the type area it is 8 feet thick, and it is known definitely only in the Danville area.

**Hillery Till Member**—The Hillery Till Member of the Banner Formation (Johnson et al., 1971, p. 195) is named for Hillery, Vermilion County, and its type locality is in the Power Plant Section (NW SW SW 21, 20N-12W). The Hillery Till Member is reddish brown, calcareous, massive, hard till. The lower part is slightly darker, and the upper commonly contains streaks of silt. The member is 14 feet thick in the Harmattan Strip Mine Section, where it overlies the Harmattan Till Member and is overlain by the Tilton Till Member. It is best known in the Danville area, where it generally rests directly on the bedrock.

**Tilton Till Member**—The Tilton Till Member of the Banner Formation (Johnson et al., 1971, p. 196) is named for Tilton, Vermilion County, and the type locality is the School House Branch Section (SE NE NE 2, 19N-12W). Where unoxidized, the Tilton Till Member is gray, calcareous, hard, silty, sandy till. The unit contains considerable silt, sand, and gravel, particularly near the upper and lower boundaries. The Tilton Till is commonly overlain at the top by a truncated weathered zone, or an oxidized zone, and in the Harmattan Strip Mine Section it overlies the Hillery Till Member. In Vermilion County the member is about 15 feet thick.

**Lierle Clay Member**—The Lierle Clay Member of the Banner Formation (Willman and Frye, 1970, p. 52) is named for Lierle Creek, Adams County (SE cor. SW 33, 1S-6W). It is predominantly accretion-gley consisting of gray clay, silt, and some sand. The Lierle is noncalcareous and is characterized by abundant pedogenic montmorillonite. It overlies the till of the Banner Formation and is overlain by deposits of Illinoian age. It is discontinuous, is less than 10 feet thick, and is exposed at many localities in western Illinois, where the surface drift is Kansan. The unit is part of the Yarmouth Soil but is an accretionary deposit made largely throughout Yarmouthian time.

## **Yarmouthian Stage**

The Yarmouthian Stage is based on the Yarmouth Soil, described by Leverett (1898c, p. 176) from its occurrence in a well section near Yarmouth, Des Moines County, Iowa. It was described as the interval of weathering and organic accumulation separating the Kansan and Illinoian glacial deposits. The adject-

## WISCONSINAN STAGE

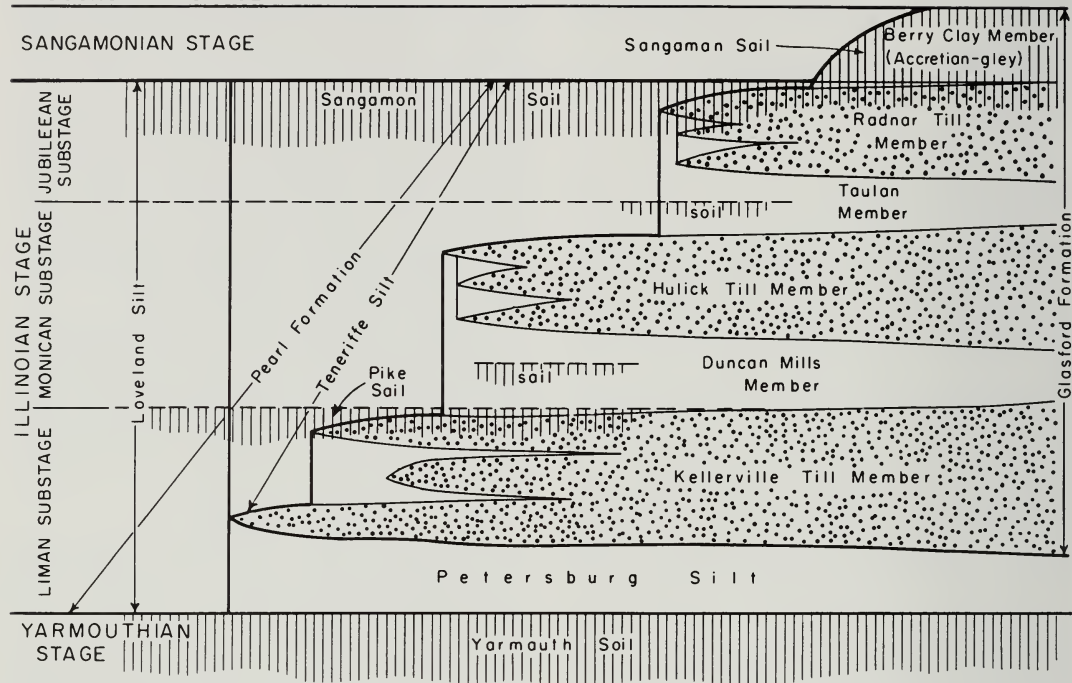


Fig. Q-7—Diagrammatic cross section showing the relations of the formations and members of Illinoian age in central and western Illinois (Willman and Frye, 1970).

tival ending was added (Frye et al., 1948) to distinguish the stage from the soil. As the original type section has not been accessible for 75 years, Willman and Frye (1970) suggested as paratype the Fort Madison Section, Lee County, Iowa (Willman et al., 1966, p. 63). The Yarmouthian Stage in Illinois is represented by the accretion-ogley of the Lierle Clay Member of the Banner Formation and by the in-situ Yarmouth Soil (fig. Q-4).

### Yarmouth Soil

The Yarmouth Soil was named and described by Leverett (1898c, p. 176) from its occurrence in a well at Yarmouth, Des Moines County, Iowa. He described the soil as the weathered zone on the Kansan drift, overlain by Illinoian deposits. In some places the soil is an in-situ profile developed in earlier deposits (fig. Q-1E), but in others it consists of accretionary deposits of fine sediment and organic material that accumulated in poorly drained areas on the surface of Kansan deposits. Such deposits are as much as 10 feet thick. This soil has been observed at many localities in Illinois, most of them in the western and central parts of the state.

### Illinoian Stage

Leverett (*in* Chamberlin, 1896) named the Illinois till sheet for the Illinoian Glacial Lobe

and later introduced the name Illinoian Stage (Leverett, 1899, p. 20-23). He included within the stage all of the deposits between the Yarmouthian and Sangamonian Stages of present usage. As Leverett did not specify a type section within the lobe, Willman and Frye (1970, p. 120) designated as paratype the Tindall School Section, Peoria County (SW SW NE 31, 7N-6E) (Willman et al., 1963, p. 54-55). In this section the Illinoian Stage is bounded at the base by the truncated Yarmouth Soil and at the top by the top of the Sangamon Soil, an in-situ soil profile in the uppermost Illinoian deposits. The Illinoian Stage is subdivided into three substages—the Liman at the base, the Monican, and the Jubileean. The three substages are all present in the paratype section. The deposits are differentiated into five formations (figs. Q-4, Q-7).

### Liman Substage

The Liman Substage (Frye et al., 1964, p. 16) is named for Lima Township, Adams County, and the type section is in the Pryor School Section (NE NE SE 11, 2N-8W). At the type section the substage is represented by the Petersburg Silt at the base with the Kellerville Till Member of the Glasford Formation

above it. In the type locality its base is defined by the contact of Petersburg Silt on the Yarmouth Soil developed in Kansan deposits, and its top is the truncated surface of the Pike Soil, which is overlain by loess deposits. At the paratype section for the Illinoian Stage (the Tindall School Section), deposits of the Liman Substage are overlain by glacial deposits of the Monican Substage.

### *Pike Soil*

The Pike Soil (Willman and Frye, 1970, p. 84) is named for Pike County, Illinois, and its type section is in the New Salem Northeast Section (NW NE SW 11, 4S-4W). In the type section the Pike Soil is developed in sediments of Liman age—the Kellerville Till Member of the Glasford Formation—and it is overlain by the Teneriffe Silt, which has the Sangamon Soil in the top. The Sangamon Soil is overlain by Wisconsinan loesses. The Teneriffe Silt at this locality is Monican and/or Jubileean in age, but from regional relations the termination of formation of the Pike Soil is inferred to be in early Monican time. The Pike Soil has a deeply developed profile, but it has been observed at only a few places in western and central Illinois.

### *Petersburg Silt*

The Petersburg Silt (Willman et al., 1963, p. 6) is named for Petersburg, Menard County, and the type section is in the Petersburg Section (NW NW NE 23, 18N-7W). The Petersburg ranges from gray to yellow-tan to purplish tan calcareous silt. The upper part is commonly massive and loess-like and contains fossil mollusks, whereas the lower part has indistinct bedding and locally contains fine sand. It rests on the top of the Yarmouth Soil, or older deposits, and is overlain by the Glasford Formation at the many localities in central and western Illinois where it occurs. In the type section it is 20 feet thick, but at most places it is less than 12 feet thick. Beyond the area of the Glasford, deposits equivalent in age to the Petersburg are part of the Loveland Silt (fig. Q-7).

### *Loveland Silt*

The Loveland Silt (Shimek, 1909, p. 405) is named for Loveland, Iowa, where it is exposed in the bluff of the Missouri River Valley. It is dominantly clayey silt, but locally contains some fine sand. It is tan to reddish brown, massive, and in most places is leached of carbonate minerals. It is bounded at the base by the top of the Yarmouth Soil, or older deposits, and at the top by the top of the Sangamon Soil (Willman and Frye, 1970). It commonly is entirely within the Sangamon Soil (fig. Q-1E). It occurs only beyond the limit of Illinoian glaciation—in extreme southern, western, and northwestern Illinois—and in most places is less than 10 feet thick. The Loveland Silt is continuous with both the Petersburg and Teneriffe Silts, which occur inside the glaciated area (fig. Q-7).

### *Pearl Formation*

The Pearl Formation (Willman and Frye, 1970, p. 60) is named for Pearl, Pike County, and the type section is

in the Pearl Prairie Section (SE SW NE 16, 7S-2W) (Frye and Willman, 1965, p. 14). The unit includes Illinoian outwash that occurs beyond the limit of Illinoian glaciation or overlies Illinoian till. It ranges from medium sand to gravel and sand and is commonly tan to gray-tan. It generally has more oxidized and cemented beds than the younger outwash. It is terminated upward by the top of the Sangamon Soil, which is commonly overlain by Wisconsinan loesses. In most places the formation is less than 40 feet thick, but in major valleys it may be significantly thicker. Geographic distribution is primarily along major valleys in central and western Illinois.

### *Glasford Formation*

The Glasford Formation (Willman and Frye, 1970, p. 52) is named for Glasford, Peoria County, and the type section is in the Tindall School Section (SW SW NE 31, 7N-6E). The formation includes glacial tills, intercalated outwash deposits of gravel, sand, and silt, and the overlying accretion-gley deposits (figs. Q-1A, B, D). It overlies the Petersburg Silt or, in the absence of that formation, the top of the Yarmouth Soil or older rocks. It is terminated upward by the top of the Sangamon Soil, where the soil is an in-situ profile developed in the top of the glacial deposits and also where the soil is an accretion deposit. Fourteen members have been described within the Glasford Formation (fig. Q-4), many of which have limited regional extent. The formation is the surface drift and almost continuously present in a large part of Illinois (fig. Q-5). It is also widely present below glacial deposits in the outer 40 miles of the region covered by Wisconsinan glaciers (Horberg, 1953). The Glasford Formation is 35 feet thick in its type section, but it ranges from a few feet to more than 150 feet thick.

**Kellerville Till Member**—The Kellerville Till Member of the Glasford Formation (Willman and Frye, 1970, p. 55) is named for Kellerville, Adams County, and the type section is in the Washington Grove School Section, 2 miles southwest of Kellerville (NW NW SW 11, 2S-5W), an exposure at the front of the Mendon Moraine. The member is till with intercalated, discontinuous zones of sand and gravel outwash and silt. It is more varied and has a higher percentage of clay minerals and a higher ratio of calcite to dolomite than the overlying members. It is as much as 150 feet thick but commonly less than 50 feet thick. It overlies the Petersburg Silt, or older deposits, and it is overlain by the Duncan Mills Member or, where it extends beyond the margins of later Illinoian glacial advances, by the Teneriffe Silt. It is differentiated in west-central, western, and northwestern Illinois.

**Duncan Mills Member**—The Duncan Mills Member of the Glasford Formation (Willman and Frye, 1970, p. 56) is named for Duncan Mills, Fulton County, and the type section is in the Enion Section, 4 miles south of Duncan Mills (NW SW SE 32, 4N-3E). In the type section the Duncan Mills Member consists of outwash sand, gravel, and some silt, and is generally deeply weathered. It is recognized as a member only where it is bounded by the Kellerville Till Member below and the Hulick Till Member above. It attains a maximum thickness of 30 feet and has been observed only in central western and west-central Illinois.

**Hulick Till Member**—The Hulick Till Member of the Glasford Formation (Willman and Frye, 1970, p. 56) is named for Hulick School, Fulton County, and the type section is in the Lewistown Section (SW SE SE 21, 5N-3E). The member, consisting of till and intercalated sand and gravel outwash, is locally more than 100 feet thick. It is bounded at the top in various areas by the Toulon, Radnor Till, or Berry Clay Members, the Teneriffe Silt, or the Pearl Formation. At

some places its top is the top of the Sangamon Soil. It rests on the Duncan Mills Member, the Kellerville Till Member, or older rocks. The clays and carbonates of the Hulick indicate derivation from the Paleozoic rocks of north-central and northeastern Illinois, and the heavy mineral assemblage is indicative of a source in western Ontario, Canada. The member occurs in central western and southwestern Illinois.

**Toulon Member**—The Toulon Member of the Glasford Formation (Willman and Frye, 1970, p. 57) is named for Toulon, Stark County, and the type section is in the Toulon Section (NW NW SW 24, 13N-5E), a borrow pit three-fourths of a mile west of Toulon. The member consists of glacially derived sand, gravel, and silt. It is differentiated only when it occurs between the Radnor Till Member above and the Hulick Till Member below. In its type section it is 9 feet thick, and it exceeds this thickness at only a few places. It has been observed in west-central and western Illinois. A minor soil in the Toulon Member forms the top of the Monican Substage.

**Radnor Till Member**—The Radnor Till Member of the Glasford Formation (Willman and Frye, 1970, p. 57) is named for Radnor Township, Peoria County, and the type section is in the Jubilee College Section (SW SW SW 7, 10N-7E). In the type section the Radnor Till is bounded at the top by the top of the Sangamon Soil, which is overlain by Wisconsinan loesses, and at its base by the Toulon Member. It consists of massive, calcareous, gray till characterized by a high illite content. It appears to be a stratigraphic equivalent of the Sterling Till Member of northwestern Illinois. In the type section it is 22 feet thick, and it exceeds this thickness only in the end moraine at its outer margin. The member occurs in central and east-central Illinois.

**Smithboro Till Member**—The Smithboro Till Member of the Glasford Formation (Jacobs and Lineback, 1969, p. 9) is named for Smithboro, Bond County, and its type locality is in the Mulberry Grove Section, 5 miles east of the town (SW SW 31, 6N-1W), where it is about 12 feet thick. The member consists of gray, compact, silty till. It is bounded below by its contact on the top of the Yarmouth Soil, or older rocks, and at the top by the overlying Mulberry Grove Member of the Glasford. It occurs widely in south-central and central eastern Illinois.

**Mulberry Grove Member**—The Mulberry Grove Member of the Glasford Formation (Jacobs and Lineback, 1969, p. 12) is named for Mulberry Grove, Bond County, and its type section is in the Mulberry Grove Section (SW SW 31, 6N-1W), where it is about 3 feet thick. The member is calcareous gray silt and fine sand containing some fossil mollusks (Leonard et al., 1971). It is bounded below by the Smithboro Till Member and above by the Vandalia Till Member. It occurs in south-central and central eastern Illinois.

**Vandalia Till Member**—The Vandalia Till Member of the Glasford Formation (Jacobs and Lineback, 1969, p. 12) is named for Vandalia, Fayette County, and the type section is in the Vandalia Bridge Section, along the Kaskaskia River, at Vandalia (NW NE SE 16, 6N-1E), where it is about 20 feet thick. The member consists of sandy till with thin lenticular bodies of silt, sand, and gravel. It is calcareous, except where weathered, generally gray, and moderately compact. It is bounded below by the Mulberry Grove, Smithboro, or older rocks, and at the top by the Hagarstown Member, younger beds, or the top of the Sangamon Soil. It commonly is 25-50 feet thick, and it occurs widely in south-central and central eastern Illinois.

**Hagarstown Member**—The Hagarstown Member of the Glasford Formation (Jacobs and Lineback, 1969, p. 12) is named for Hagarstown, Fayette County, 5 miles west of the type section, the Hickory Ridge Section (SW NW 30, 6N-1E). The member consists of gravelly till, poorly sorted gravel, well sorted gravel, and sand (fig. Q-1D). Stratigraphically it lies above the Vandalia Till Member and is bounded at the top by the top of the Sangamon Soil. It commonly occurs in

elongate ridges in south-central Illinois. In the type locality it is about 30 feet thick, but it is more than 100 feet thick in some of the higher ridges.

**Roby Silt Member**—The Roby Silt Member of the Glasford Formation (Johnson, 1964, p. 8) is named for Roby, Christian County, and the type section is in the Roby Section, Sangamon County (NW SE NE 14, 15N-3W). The member consists of tan and gray calcareous silt and silty clay and contains fossil mollusks (Leonard et al., 1971). It is bounded below by the Hulick Till Member, or the Vandalia Till Member, and is overlain by the Radnor Till Member. The unit is commonly 2-5 feet thick, and it is widely distributed in central Illinois.

**Ogle Till Member**—The Ogle Till Member of the Glasford Formation (Frye et al., 1969, p. 24) is named for Ogle County, Illinois, and the type section is in the Haldane West Section (NE NE NE 25, 24N-7E). The member consists largely of till that varies in mineral and textural compositions. The till is generally sandy and silty, tan to gray-brown, and discontinuously interstratified with sand and gravel. The member is generally less than 20 feet thick, and it is extensively eroded. It occurs primarily in Winnebago, Stephenson, Carroll, and Ogle Counties. In most places it rests directly on bedrock. Where the Ogle Till is the surface drift, the Sangamon Soil was developed in its top, and the soil is overlain by loesses of Wisconsinan age. In many places, however, the soil was eroded before deposition of the loesses. Locally the Ogle has been found beneath the Argyle Till Member of the Winnebago Formation.

**Winslow Till Member**—The Winslow Till Member of the Glasford Formation (Frye et al., 1969, p. 25) is named for Winslow, Stephenson County, and the type section is in roadcuts west of Winslow (SW SE SW 21, 29N-6E). In the type section it consists of 12 feet of dark gray clayey till resting directly on bedrock and overlain by thin loesses of Wisconsinan age. At a few places the Sangamon Soil occurs in the top, but the soil has been eroded from much of the area. The Winslow is limited to Stephenson and Jo Daviess Counties. It may be a lithologic variant of the Ogle Member or a stratigraphic equivalent of the Sterling Member, but it is distinctly different from both in composition.

**Sterling Till Member**—The Sterling Till Member of the Glasford Formation (Frye et al., 1969, p. 25) is named for Sterling, Whiteside County, and the type section is in the Emerson Quarry Section 2 miles west of Sterling (SE NW SE 13, 21N-6E). The unit consists of gray, silty, calcareous till with an exceptionally high illite content. It overlies the Ogle Till Member, or older rocks, and is bounded at the top by the Sangamon Soil. It is overlain by the Winnebago Formation, the Wedron Formation, or loesses of Wisconsinan age. The Sterling occurs primarily in Whiteside and Lee Counties. It is as much as 40 feet thick in the Sterling area but generally is thinner. It is stratigraphically equivalent to the Radnor Till Member to the south.

**Berry Clay Member**—The Berry Clay Member of the Glasford Formation (Willman and Frye, 1970, p. 54) is named for Berry, Sangamon County, and the type section is in the Rochester Section, 3 miles west of Berry (NW SE NW 34, 15N-4W). The member is an accreted soil of clay and silt containing a few small pebbles. It is gray to dark gray, leached of carbonate minerals, and generally 2-5 feet thick. It is bounded at the top by the top of the Sangamon Soil and at the base by weathered till of the Glasford Formation. It occurs at isolated localities throughout the area of Illinoian drift (figs. Q-5, Q-7).

## Monican Substage

The Monican Substage of the Illinoian Stage (Willman and Frye, 1970, p. 120) is

named for Monica, Peoria County, and its type section is in the Jubilee College Section (SW SW SW 7, 10N-7E). In the type section, the deposits of the substage are the Hulick Till Member and the lower part of the Toulon Member of the Glasford Formation. The latter is outwash sand, silt, and gravel, which is oxidized and locally leached in the top. At the type section, the deposits rest unconformably on Pennsylvanian shales, but at the paratype for the Illinoian Stage (Tindall School Section) they occur between sediments of the Liman and Jubileean Substages. The Monican Substage is defined as consisting of the Illinoian deposits above the Pike Soil, and its top is a minor unnamed soil in the Toulon, which is overlain by deposits of the Jubileean Substage.

### *Teneriffe Silt*

The Teneriffe Silt (Willman and Frye, 1970, p. 60) is named for Teneriffe School, Pike County, and the type section is in the New Salem Northeast Section (NW NE SW 11, 4S-4W). The formation contains all the silts overlying till of the Glasford Formation and is bounded at the top by the top of the Sangamon Soil. Locally it rests on the top of the Pike Soil. It is assigned to both the Monican and Jubileean Substages. The unit is fine to coarse silt and locally contains some sand and clay. The Teneriffe is not differentiated beyond the limit of Illinoian glaciation (fig. Q-7), where it is equivalent to the upper part of the Loveland Silt. The formation occurs in central western and south-central Illinois (fig. Q-1C) and at many places is overlain by the Roxana Silt.

### *Jubileean Substage*

The Jubileean Substage of the Illinoian Stage (Willman and Frye, 1970, p. 120) is named for Jubilee College State Park, Peoria County, and its type section is in the Jubilee College Section (SW SW SW 7, 10N-7E). At the type section it consists of the upper silts of the Toulon Member and the overlying Radnor Till Member of the Glasford Formation. It overlies a minor soil developed in deposits of Monican age, and its top is the top of the in-situ Sangamon Soil, which is overlain by Wisconsinan deposits.

### *Sangamonian Stage*

The name "Sangamon interglacial stage" was proposed by Leverett (1898b, p. 176) for exposures in Sangamon County. The name "Sangamonian Stage" was adopted in Illinois in 1960 (Frye and Willman, 1960, p. 4). The interglacial stage was based on a soil that occurs on tills of Illinoian age and is overlain by

loesses of Wisconsinan age. Leverett's (1898b) type section was a locality in northwestern Sangamon County described by Worthen (1873, p. 307), but it has not been accessible for three-quarters of a century. For that reason Willman and Frye (1970, p. 121) proposed two paratype sections, the Rochester Section in Sangamon County (an accretion-ogley) (NW SE NW 34, 15N-4W) and the Chapin Section in adjacent Morgan County (an in-situ soil profile) (SW NE NW 8, 15N-11W). The stage is based on the soil-stratigraphic unit, typified by these two localities, that serves to define the interval separating the Illinoian and Wisconsinan glacial stages. Sangamonian deposits are predominantly accretion-ogley of the Berry Clay Member of the Glasford Formation, which also is part of the Sangamon Soil. Minor amounts of organic debris are associated with the accretion-ogley deposits, but the peat and peaty silt beds called Sangamon in early reports are Wisconsinan and are assigned to the Farmdalian Substage.

### *Sangamon Soil*

The Sangamon Soil was defined by Leverett (1898b) on the basis of a soil described by Worthen (1873) from a well in Sangamon County, Illinois. The soil is characterized by both a deeply developed in-situ profile on deposits of Illinoian age (Chapin Section) and a soil composed of accretion deposits above tills of Illinoian age (Rochester Section). The soil ranges from an in-situ solum more than 5 feet deep with a red-brown B-horizon (fig. Q-1A, E) to an accretion deposit of gray leached silt and clay containing a few small pebbles. The soil is developed in deposits of a wide range of ages and character. It is almost continuously present on the Illinoian drift (fig. Q-2), and in places it occurs on older deposits where the Illinoian is absent. It is also found in many localities where it is overlain by Wisconsinan drift.

### *Wisconsinan Stage*

The term "Wisconsinan Stage" is derived (fig. Q-6) from the East-Wisconsin formation proposed by Chamberlin (1894, p. 763). In 1895 (p. 275) he changed the name to Wisconsin formation, and in 1899 (p. 20, 185) Leverett proposed the change to Wisconsin stage. The initial definition was based largely on the pattern of end moraines from the Lake Michigan glacial lobe and included only part of the sequence now included in the stage (fig. Q-2). In 1948 Leighton (*in* Wascher et al., 1948, p. 390) applied the name "Farmdale" to the loess previously called Late Sangamon loess and included it in the Wisconsin stage. In 1960 (p. 5) Frye and Willman proposed an expanded definition of the stage, and the present definition of the Wisconsinan

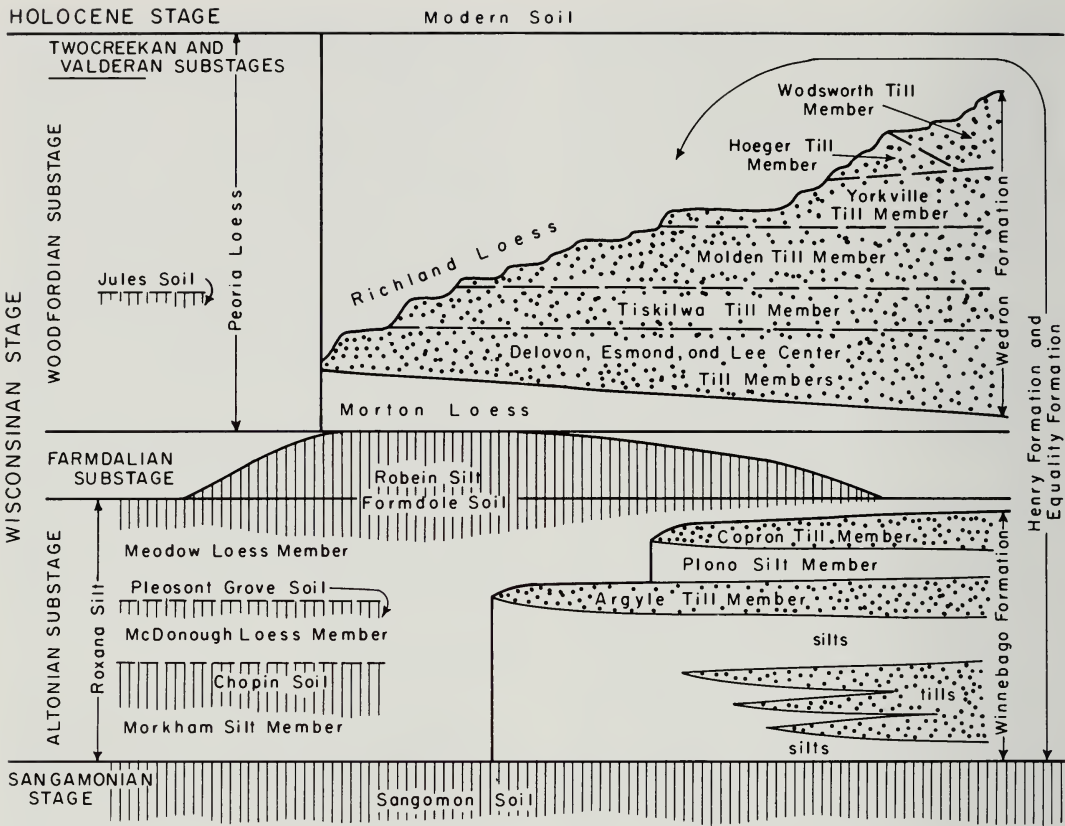


Fig. Q-8—Diagrammatic cross section showing the relations of the formations and members of Wisconsin age in northern and western Illinois (Willman and Frye, 1970).

Stage was proposed in 1968 (Frye et al., 1968b, p. E1). The Wisconsinan Stage is bounded at the base by the contact of the Roxana Silt on the top of the Sangamon Soil (approximately 75,000 radiocarbon years B.P. [Frye et al., 1974a, p. 12]), and at the top by the contact of the youngest glacial tills with overlying lacustrine deposits in northeastern Wisconsin (approximately 7000 radiocarbon years B. P. [Frye and Willman, 1970, p. 126]). The Cottonwood School Section in Cass County (cen. E line 11, 18N-11W) was suggested by Willman and Frye (1970, p. 121) as a paratype for the stage in Illinois. The Wisconsinan Stage is subdivided into five substages, and the deposits are differentiated into 16 formations, but six of them are dominantly Holocene in age (figs. Q-4, Q-8). The Wisconsinan Stage is represented in all parts of Illinois.

*Altonian Substage*

The Altonian Substage (Frye and Willman, 1960, p. 5), the oldest subdivision of the Wisconsinan Stage, is named for Alton, Madison County, and the type section, which consists of Roxana Silt, is in the Alton Quarry Section (SE SW NE 10, 5N-10W) (Leonard and Frye, 1960, p. 24). In the type locality the base of the Altonian Substage is at the contact of the Markham Silt Member of the Roxana Silt with the top of the Sangamon Soil. The top of the Altonian is the contact of the Robein Silt and the Roxana Silt, or the top of the Farmdale Soil developed in Roxana Silt. Elsewhere in Illinois the substage includes deposits of till (Winnebago Formation), outwash (Henry Formation), and lacustrine deposits (Equality Formation). Deposits of Altonian age are widely distributed over Illinois.

## Roxana Silt

The Roxana Silt (Frye and Willman, 1960, p. 5) is named for Roxana, Madison County, and the type section is the Pleasant Grove School Section in the bluff of the Mississippi River Valley (SW NE SE 20, 3N-8W) (fig. Q-1C). The formation rests on the top of the Sangamon Soil (developed in Teneriffe Silt or older deposits), and it terminates upward at the base of the Robein Silt or the top of the in-situ Farmdale Soil (developed in the Roxana), which is overlain by Peoria Loess. The Roxana Silt and the overlying Robein Silt were called Late Sangamon Loess in early reports and later named Farmdale Loess and assigned to the Wisconsin Stage (Leighton, *in* Wascher et al., 1948; Leighton and Willman, 1949, 1950). The member is largely loess, but it contains some colluvium at the base and locally some eolian sand. It is pinkish tan to yellow-gray (Frye et al., 1962) and has a distinctive mineral composition (Glass et al., 1968). It is 48 feet thick in the type section, but it thins rapidly back from bluff exposures. Where thick, it contains a distinctive molluscan fauna (Leonard and Frye, 1960), and it has been subdivided into three members, the Markham Silt Member at the base, the McDonough Loess Member, and the Meadow Loess Member. Where the Roxana is thinner than 7-8 feet thick the members generally cannot be differentiated because of pedological alteration (figs. Q-1A, E). Even where only a foot or two thick, it is generally darker brown and more clayey than the Peoria Loess. The formation occurs extensively outside the limits of Woodfordian glaciation and locally is found buried by Woodfordian drift.

**Markham Silt Member**—The Markham Silt Member of the Roxana Silt (Willman and Frye, 1970, p. 62) is named for the town of Markham, 4 miles west of Jacksonville, Morgan County, and the type section is in the Chapin Section (SW NE NW 8, 15N-11W). The unit generally consists of colluvium of silt with some sand and a few small pebbles (Frye et al., 1974a), but locally it may be entirely silt or sand. It rests on the top of the Sangamon Soil or on an erosional surface truncating the Sangamon Soil, and it is terminated at the top by the top of the Chapin Soil, which is overlain by the McDonough Loess Member. The Markham is gray-brown, lies within the profile of the Chapin Soil, is commonly 1-3 feet thick, and is widely present in western and central Illinois.

**McDonough Loess Member**—The McDonough Loess Member of the Roxana Silt (Willman and Frye, 1970, p. 62) is named for McDonough Lake on the Mississippi River floodplain in Madison County, and the type section is in the Pleasant Grove School Section, the same as for the formation (fig. Q-1C). The member consists of gray to tan loess, commonly leached, bounded at the base by the top of the Chapin Soil or older deposits and at the top by the top of the Pleasant Grove Soil, which is overlain by the Meadow Loess Member. The member is generally recognizable only in the thick loess deposits adjacent to the major valleys of central, southern, and western Illinois, and it is 5 feet or less thick.

**Meadow Loess Member**—The Meadow Loess Member of the Roxana Silt (Willman and Frye, 1970, p. 63) is named for Meadow Heights, part of Collinsville, Madison County, and the type section, like that of the formation, is in the Pleasant Grove School Section (fig. Q-1C). The member is loess, and where thick along the bluffs of the Illinois and Mississippi Rivers of central and southern Illinois it has three recognizable zones—pink-tan zones at the top and base and a gray-tan zone in the middle. Where thick and calcareous, it contains a distinctive fauna of fossil mollusks that has been radiocarbon dated at several localities (Leonard and Frye,

1960). Its heavy mineral suite and clay mineral composition differ from those of other loess deposits (Frye et al., 1962). It rests on top of the Pleasant Grove Soil developed in the McDonough Loess Member, or on older deposits, and it is bounded at the top by the in-situ Farmdale Soil, by the Robein Silt, or by younger formations. The member is 43 feet thick at its type locality, but it thins to a few feet at distances of 15 miles or more from the source valleys.

## Chapin Soil

The Chapin Soil (Willman and Frye, 1970, p. 86) is named for Chapin, Morgan County, and the type section is in the Chapin Section (SW NE NW 8, 15N-11W). It is an in-situ soil developed in the colluvium and silt of the Markham Silt Member of the Roxana Silt. The soil generally is grayish brown and rests either on the A-horizon of the Sangamon Soil or on a truncated Sangamon Soil. The profile rarely is more than 2 feet thick, in contrast to the thicker Sangamon profile below (Frye et al., 1974a). The Chapin Soil occurs in western and central Illinois.

## Pleasant Grove Soil

The Pleasant Grove Soil (Willman and Frye, 1970, p. 87) is named for Pleasant Grove School and the type section, like that of the Roxana Silt, is in the Pleasant Grove Section, Madison County. The soil at the type locality is an immature, or A-C, profile developed in silt of the McDonough Loess Member of the Roxana Silt. The solum is generally gray to gray-brown and lacks a textural B-horizon. The soil has been observed only adjacent to the major valleys of central and western Illinois.

## Winnebago Formation

The Winnebago Formation (Frye and Willman, 1960, p. 5; Frye et al., 1969, p. 25) is named for Winnebago County, and the type section is on the east side of Rockford in the Rock Valley College Section (SW NW SW 10, 44N-2E) and in cores of near-by borings (Nos. 2 and 5) on the Northwest Tollway (Kempton, 1963). The name Winnebago was introduced as a replacement for the term "Farmdale" (Shaffer, 1956). The formation includes glacial till and intercalated silt, gravel, and sand. It is subdivided into three named members, the Argyle Till Member at the base, the Plano Silt Member, and the Capron Till Member, which overlie unnamed till, sand, and gravel members that occur in the buried valleys and are not exposed. The formation is bounded below by the top of the Sangamon Soil, and at the top by the top of the in-situ Farmdale Soil. It ranges from a few feet to as much as 400 feet thick where it is the filling of deep bedrock valleys. The formation is exposed at the surface only in central northern Illinois (fig. Q-5). The Lemont drift (Bretz, 1955), tentatively assigned to this formation, is discussed with the Valparaiso Drift.

**Argyle Till Member**—The Argyle Till Member of the Winnebago Formation (Frye et al., 1969, p. 26; Willman and Frye, 1970, p. 63) is named for Argyle, Winnebago County, and the type section is in the Rock Valley College Section, the same as the type section for the formation. The till is exceptionally sandy, pinkish tan or salmon colored, massive, and calcareous. It is overlain by the Plano Silt Member, and it overlies unnamed silts and tills of the Winnebago Formation. It occurs only in central northern Illinois (fig. Q-5).

**Plano Silt Member**—The Plano Silt Member of the Winnebago Formation (Kempton and Hackett, 1968, p. 31; Willman and Frye, 1970, p. 64) is named for Plano, Kendall County, and the type section is in the Big Rock Creek Section (SE NE 1, 37N-6E) where the member is 7 feet thick. The member consists of silt, silt rich in organic material, and peat. It overlies the Argyle Till and underlies the Capron Till, and it is recognized only in the area where the Capron Till is present.

**Capron Till Member**—The Capron Till Member of the Winnebago Formation (Frye et al., 1969, p. 26; Willman and Frye, 1970, p. 64) is named for Capron, Boone County, and the type section is in the Capron North Section (NE SE SE 23, 46N-4E). Its upper part is gray, calcareous sandy till and the lower part is silty till. It rests on Plano Silt or Argyle Till and is topped by an immature soil profile (Farmdale Soil) overlain by Peoria Loess. It occurs only in central northern Illinois (fig. Q-5).

## Henry Formation

The Henry Formation (Willman and Frye, 1970, p. 70) is named for Henry, Marshall County, and the type exposure is in a gravel pit along Illinois Highway 29, 2 miles north of Henry (SE SE 32, 14N-10E), where 30 feet of sand and gravel overlain by 2 feet of the Richland Loess and the Modern Soil are exposed. The formation consists of glacial outwash of sand and gravel. In places it contains a few thin silt beds. The thickness of the formation varies greatly; in the major valleys it locally exceeds 100 feet. The formation rests on Woodfordian or older rocks, and it is overlain by Richland or Peorian Loess, the Equality Formation, or Holocene deposits. Although in some areas the formation is continuous with sand and gravel deposits that intertongue with tills of the Winnebago and Wedron Formations, vertical cut-offs are used to put the tongues in the Wedron or Winnebago Formations, and the Henry Formation is never overlain by till (fig. Q-8). Ideally, the formation is bounded at the base by the top of the Sangamon Soil, but such exposures are rarely observed; in some valleys it contains deposits older than Wisconsinan in its lower part. The formation is subdivided into three members, which are genetic units that differ in lithology—the Batavia Member (outwash plains), the Mackinaw Member (valley trains), and the Wasco Member (ice-contact deposits). The Henry Formation occurs extensively in the area of Wisconsinan glaciation and beyond that area along the outwash-carrying valleys (fig. 11).

**Batavia Member**—The Batavia Member of the Henry Formation (Willman and Frye, 1970, p. 71) is named for Batavia, Kane County, and the type exposure is in a gravel pit, 8 miles north of Batavia (SW 1, 40N-8E), in outwash deposited in front of the West Chicago Moraine. The Batavia Member is an upland unit of outwash sand, gravel, and silt, largely deposited along the fronts of many Wisconsinan moraines in discontinuous sheet-like deposits. The member rarely exceeds 30 feet thick, and it has sharp local variations in both thickness and texture. It rests on units of the Wedron Formation, or older deposits, and is commonly overlain only by a few feet of Richland Loess. It occurs in and bordering the area of Wisconsinan glaciation.

**Mackinaw Member**—The Mackinaw Member of the Henry Formation (Willman and Frye, 1970, p. 71) is named for Mackinaw, Tazewell County, and the type section is in a gravel pit on the southwest side of Mackinaw (NE NW 19, 24N-2W). The member consists of sand, pebbly sand, and

gravel deposited as outwash valley trains leading outward from Wisconsinan glacier fronts and now preserved in terraces and beneath Holocene deposits. The materials are well sorted and regularly bedded. At the type locality the member is 30 feet thick, but at places it is more than 100 feet thick. The member rests on rocks ranging from the Wedron Formation to Paleozoic bedrock. It is generally overlain only by thin Richland Loess in the area of Wisconsinan glaciation and by the Peoria Loess outside that area. It occurs along many valleys throughout Illinois (fig. Q-2).

**Wasco Member**—The Wasco Member of the Henry Formation (Willman and Frye, 1970, p. 72) is named for Wasco, Kane County, and the type section is in a gravel pit along the Chicago Great Western Railroad (SE NW 24, 40N-7E). The Wasco consists of ice-contact sand and gravel, largely in kames, eskers, and deltas, and is characterized by lateral and vertical variations in grain size, sorting, bedding, and structure. At some localities the deposit is largely cobbles and boulders. Lenses of till and beds of silt occur in some deposits. The thickness varies greatly. The member generally rests on the Wedron Formation but locally overlies older deposits. It is commonly overlain by thin Richland Loess. It occurs discontinuously throughout the area of Wisconsinan glaciation.

## Equality Formation

The Equality Formation (Willman and Frye, 1970, p. 72) is named for Equality, Gallatin County, and the type section is in the Saline River Section (SE cor. SW 27, 9S-7E). The formation consists of lacustrine silt, clay, and sand underlying a lake plain or beach complex of the present land surface. It was deposited during Wisconsinan time in (1) slackwater lakes, principally in valleys tributary to the Mississippi, Wabash, and Ohio Rivers in southern Illinois, (2) in shallow lakes produced by flooding between moraines, and (3) in ice-front lakes in northern Illinois (fig. 11). The formation is subdivided into the Carmi Member, dominantly silt and clay, and the Dolton Member, dominantly sand. It includes deposits of Altonian and Woodfordian age. Extensive molluscan faunas have been described from the lacustrine deposits (Frye et al., 1972). In the type region, the thickest sequence of Equality deposits available for study was 52 feet in the Equality Northeast Section (Frye et al., 1972), but well logs suggest that the formation may exceed 100 feet locally. The formation rests on Woodfordian or older deposits and its top is at the surface, except in local areas where Holocene formations cover it. In southern Lake Michigan it is overlain by the Lake Michigan Formation. Many individual glacial lakes, shorelines, spits, bars, and beaches have been named, but they are not stratigraphic units (Willman and Frye, 1970).

**Carmi Member**—The Carmi Member of the Equality Formation (Willman and Frye, 1970, p. 74) is named for Carmi, White County, and the type section is an exposure along Crooked Creek 4 miles north of Carmi (NE cor. SW 21, 4S-10E). The type section of this member occurs in the deposits of glacial Lake Little Wabash. However, the deposits, their fauna, and clay mineral composition have been much more intensively studied in the deposits of Lake Saline in Gallatin County to the south (Frye et al., 1972). The deposits there are clay and silt, with some sand, commonly 20-40 feet thick but locally as much as 100 feet. They partially fill, or drown, an extensive system of valleys that were dammed by aggradation of the Ohio and Wabash Valleys. The Carmi occurs throughout the state in large areas covered by Wisconsinan lakes and also in many smaller areas in the region of Wisconsinan glaciation in northern Illinois.

**Dolton Member**—The Dolton Member of the Equality Formation (Willman and Frye, 1970, p. 74) is named for Dolton, Cook County, and the type section is an exposure of 8 feet of sand at the top of a clay pit (S $\frac{1}{2}$  NE 3, 36N-14E). The Dolton is dominantly sand with local beds of silt and gravel, and most of it was deposited in beaches and bars. It is differentiated only where it is the surficial deposit of the Equality Formation. It is best developed in Cook County, where it is associated with the several beaches of Lake Chicago (Bretz, 1955).

### *Farmdalian Substage*

The Farmdalian Substage (Leighton and Willman, 1950, p. 602; Frye and Willman, 1960, p. 6) is named for Farmdale, Tazewell County, and the type section is in the Farm Creek Section (NE SW SE 30, 26N-3W). The substage was defined in more detail in 1968 (Frye et al., 1968b, p. E15) and in 1970 (Willman and Frye, p. 125). The substage includes the deposits made during the span of time represented by the Robein Silt at the type section (28,000-22,000 radiocarbon years B.P.), where the Robein Silt overlies the Roxana Silt and is terminated upward by the top of the Farmdale Soil. It is overlain by the Morton Loess. The substage also comprises the Peddicord Formation and the Farmdale Soil. The deposits have been extensively radiocarbon dated in Illinois.

### *Robein Silt*

The Robein Silt (Willman and Frye, 1970, p. 64) is named for Robein, Tazewell County, and the type section is in the Farm Creek Section (NE SW SE 30, 26N-3W) (fig. Q-1B). It was called Farmdale Silt in some reports (Frye and Willman, 1960). The Robein is brown, gray, dark gray to black, leached silt. It contains abundant organic material, which differentiates it from the Roxana Silt below. It is part of the Farmdale Soil and is Farmdalian in age. It rests on the Roxana Silt, the Peddicord Formation, or the Winnebago Formation, and it is overlain by the Peoria Loess, Morton Loess, or the Wedron Formation. The Robein ranges from a few inches to more than 5 feet thick. It is discontinuous but widely distributed in Illinois.

### *Peddicord Formation*

The Peddicord Formation (Willman et al., 1971, p. 4) is named for Peddicord School, La Salle County, and the type section is in the Wedron Section (SE SW 9, 34N-4E) (Willman and Frye, 1970) (fig. Q-1B). The formation consists of gray and pinkish tan, calcareous, lacustrine silts, and it contains fossil mollusks (Leonard and Frye, 1960). It is Farmdalian in age. The formation has been observed only in the upper Illinois Valley, where it overlies the Sangamon Soil or bedrock and is overlain by the Robein Silt or the Wedron Formation.

### *Farmdale Soil*

The Farmdale Soil was named for Farmdale, Tazewell County (Willman and Frye, 1970, p. 87), and the type

section is in the Farm Creek Section (NE SW SE 30, 26N-3W). In the type section it is an organic soil represented by the Robein Silt. It is brown to black and lacks a textural B-horizon. This unit occurs widely over Illinois and occurs both as an organic soil and as an in-situ profile developed in Roxana Silt. It is overlain by the Morton Loess, by the Peoria Loess, or by the Wedron Formation.

### *Woodfordian Substage*

The Woodfordian Substage (Frye and Willman, 1960, p. 6-7) is named for Woodford County, Illinois, where it is the surface deposit over nearly the entire county. Glaciers of the Lake Michigan and Erie Lobes (figs. Q-9, Q-10) covered northeastern Illinois during Woodfordian time. The substage is based on the sequence of deposits above the contact of the Morton Loess on the Robein Silt in the type locality of those formations and extending upward to the base of the Two Creeks deposits, as typically exposed in east-central Wisconsin (Thwaites and Bertrand, 1957; Frye et al., 1968b). The substage includes the deposits of six formations, as well as parts of several dominantly Holocene formations (figs. Q-4, Q-8). Two of the six formations (Henry and Equality) include earlier Wisconsinan deposits and were described under the Altonian Substage. The molluscan fauna of the Woodfordian Substage, largely from the Peoria Loess, has been described (Leonard and Frye, 1960). Many radiocarbon dates have been determined from several deposits of the substage, including those adjacent to the lower and upper contacts, and they indicate a time span from 22,000 to 12,500 radiocarbon years B.P. The Woodfordian includes deposits that earlier were assigned to the Iowan, Tazewell, Cary, and Mankato Substages (fig. Q-6).

### *Peoria Loess*

The Peoria Loess (Leverett, 1898a, p. 246; Kay and Leighton, 1933, p. 673) is named for Peoria, Peoria County, from exposures in the bluffs of the Illinois River Valley. The term "Peorian" was first used by Leverett (1898a) for an interglacial stage. Kay and Leighton (1933) restricted Peorian to the loess deposits outside the Shelbyville Morainic System, as is still the practice. Frye and Leonard (1951, p. 128) made it a rock-stratigraphic unit—Peoria Loess—which use subsequently was adopted in Illinois (Frye and Willman, 1960, p. 7). As a type section had not been described, Willman and Frye (1970, p. 65-66, 188-189) designated the Tindall School Section, south of Peoria in the west bluff of the Illinois Valley, as the type section (SW SW NE 31, 7N-6E). The formation consists of massive, well sorted silt, ranging from coarse in the valley bluffs to fine in uplands distant from the bluffs. It locally contains some fine to medium sand in the bluff areas. Where thick it is calcareous, except in the Modern Soil profile at the top; where thin it is all noncal-

careous. The zone from which carbonates are leached varies from 3-4 feet thick at the northern end of the state to 15-20 feet at the southern end. In thick sections along the Illinois Valley, the Jules Soil occurs in the upper part, several feet below the Modern Soil. The Peoria Loess ranges in thickness from as much as 100 feet to only a foot or two, thinning away from the bluffs (figs. 11, Q-1C) (Smith, 1942; Willman and Frye, 1970). The fossil mollusks (Leonard and Frye, 1960) and clay mineral composition (Frye et al., 1962, 1968a) have been described, and a group of radiocarbon dates indicate a span of time from approximately 22,000 B.P. to 12,000 B.P. Peoria Loess is physically continuous with both the Morton Loess and the Richland Loess (fig. Q-8), which occur within the area of Woodfordian glaciation. The Peoria Loess occurs on the upland areas and valley walls of nearly all of Illinois outside the area of Woodfordian glaciation.

## Morton Loess

The Morton Loess (Frye and Willman, 1960, p. 7) is named for Morton, Tazewell County, and the type section is in the Farm Creek Railroad-cut Section (cen. 31, 26N-3W) (fig. Q-1A). The unit was formerly called Peorian loess (Alden and Leighton, 1917) and later Iowan loess (Leighton, 1933; Leighton and Willman, 1950). It occurs above the Robein Silt or the Farmdale Soil developed in Roxana Silt and lies below the Wedron Formation. It is massive, calcareous silt, gray to gray-tan and locally fossiliferous (Leonard and Frye, 1960). It ranges up to 10 feet thick. It occurs only within the area of Woodfordian glaciation, but it is physically continuous with the lower part of the Peoria Loess, which lies outside that area (fig. Q-8). Radiocarbon dates indicate a time span from 20,000 to 22,000 years B.P.

## Wedron Formation

The Wedron Formation (Frye et al., 1968b, p. E16) is named for Wedron, La Salle County, and the type section is in the Wedron Section (fig. Q-1B) in the Wedron Silica Company pit (SE SW 9, 34N-4E) (Willman and Payne, 1942, p. 148, 307; Willman and Frye, 1970, p. 190). The formation consists of those deposits of glacial till and outwash that extend upward from their contact on the Morton Loess to the top of the till below the Two Creeks deposits at Two Creeks, Wisconsin (Thwaites and Bertrand, 1957). Although largely till, the Wedron contains numerous intercalated beds of outwash gravel, sand, and silt (fig. Q-1A, B). In Illinois the formation is subdivided into 12 members (fig. Q-4) on the basis of the lithology of successive sheets of till. Before 1968, the deposits included in the Wedron Formation were subdivided into drifts or drift formations, lithologically distinct units named for the moraine marking the outer margin of the particular drift (Culver, 1922a; Fisher, 1925; Willman and Payne, 1942; Frye et al., 1965). The gray silty till of the Esmond, Lee Center, and Delavan Till Members was the Shelbyville drift; the pink sandy till of the Tiskilwa Till Member was the Bloomington drift; the yellow-gray silty to sandy till of the Malden Member was the Normal and Cropsey drifts; the medium to dark gray clayey till of the Yorkville Till Member was the Marseilles and Minooka drifts; and the yellow-gray gravelly to clayey till of the Haeger and Wadsworth Till Members was the Valpa-

raiso and Lake Border drifts. The youngest, or uppermost, beds of the Wedron do not occur in Illinois but are exposed in eastern Wisconsin. The formation spans all but the earliest part of the Woodfordian Substage of the Wisconsin Stage. Its thickness ranges widely, up to as much as 250 feet. Approximately 60 feet of deposits is exposed in the type section. The formation is widely distributed in the northeast quadrant of Illinois (fig. Q-5), where it includes most of the materials of the many prominent Woodfordian moraines, which are described as drift units in the section on morphostratigraphic classification (fig. Q-10).

**Esmond Till Member**—The Esmond Till Member of the Wedron Formation (Frye et al., 1969, p. 26; Willman and Frye, 1970, p. 67) is named for Esmond, De Kalb County. The type section is in roadcuts 10 miles north of Esmond (NW SW NW 27, 43N-2E, Winnebago County) and borings at Greenway School, near Esmond. The upper part of the till is silty, but the lower part is more clayey. It is gray and calcareous, and its clay mineral content is characterized by being exceptionally high in illite. The member overlies the Morton Loess, or the sandy Argyle Till Member of the Winnebago Formation where the Morton is absent. It is overlain by the pink-tan deposits of the Tiskilwa Till Member of the Wedron Formation or by Richland Loess. It is discontinuous, rarely exceeds 25 feet thick, and it is the surface drift only in the Dixon Sublobe in north-central Illinois (figs. Q-5, Q-9).

**Lee Center Till Member**—The Lee Center Till Member of the Wedron Formation (Frye et al., 1969, p. 26; Willman and Frye, 1970, p. 68) is named for Lee Center, Lee County, and the type section is a roadcut 5 miles northwest of Lee Center (SE SW NW 31, 21N-10E). In the type section it consists of 8 feet of calcareous, gray, silty till that underlies 4 feet of leached, brown silt of the Richland Loess. The Lee Center Till is bounded at the top by the sharply contrasting pink-tan Tiskilwa Till Member. It overlies the Morton Loess. It occurs primarily in the Green River Sublobe (figs. Q-5, Q-9), where it is thin, discontinuous, and extensively eroded by the meltwaters of Woodfordian glaciers.

**Delavan Till Member**—The Delavan Till Member of the Wedron Formation (Willman and Frye, 1970, p. 68) is named for Delavan, Tazewell County, and the type section is in roadcuts along Illinois Highway 121, 4 miles east of Delavan (SW 16, 22N-3W). The member consists of gray, calcareous, silty, illitic till that attains a maximum thickness of about 200 feet in the Shelbyville Moraine System. It overlies the Morton Loess and is overlain by the distinctive pinkish tan till of the Tiskilwa Till Member. It is judged to be equivalent to the Lee Center and Esmond Till Members farther north. Beyond the limit of the Tiskilwa Till Member, the Delavan is overlain by Richland Loess. It occurs in the Peoria Sublobe and is best exposed in Tazewell and McLean Counties (figs. Q-1A, Q-5).

**Tiskilwa Till Member**—The Tiskilwa Till Member of the Wedron Formation (Willman and Frye, 1970, p. 68) is named for Tiskilwa, Bureau County, and the type section is the Buda East Section (SE SE SW 31, 16N-8E). The till is sandy, pink-tan to reddish tan-brown, and commonly is 100-150 feet thick in the higher parts of the Bloomington Moraine System. It is bounded above by the more illitic, tan to yellow-gray till of the Malden Till Member, and below by the gray till of the Delavan, Lee Center, or Esmond Till Members. It is one of the most extensive members of the Wedron Formation, extending from Bloomington in McLean County northward to the Wisconsin state line (fig. Q-5).

**Malden Till Member**—The Malden Till Member of the Wedron Formation (Willman and Frye, 1970, p. 69) is named for Malden, Bureau County, and the type section is in the Malden South Section (SW SE SE 5, 16N-10E). The member consists of silty and sandy, yellow-gray to gray-tan till, with discontinuous beds and lenses of gravel and sand. In some

areas it grades upward to clayey till. It is bounded at the base by the Tiskilwa Till Member and is overlain by the clayey Yorkville Till Member or, where the Malden Member is the surface drift, by the Richland Loess. At the type locality the member is 25 feet thick, but it is 50-100 feet thick under the crests of some moraines. It is extensively exposed from McLean County northward to Kane County (fig. Q-5).

**Yorkville Till Member**—The Yorkville Till Member of the Wedron Formation (Willman and Frye, 1970, p. 69) is named for Yorkville, Kendall County, and the type section is in roadcuts at the intersection of Illinois Highways 47 and 71, 1 mile south of Yorkville (SE SE SE 5, 36N-7E). The member is a clayey, greenish gray to dark gray till characterized by abundant small dolomite pebbles. The Yorkville Member is as much as 200 feet thick in the Marseilles Morainic System, in and east of which it is extensively exposed (fig. Q-5). It overlies the Malden Till Member and is overlain by the Wadsworth and Haeger Till Members, the Richland Loess, or in extensive areas by the lake deposits of the Equality Formation (fig. Q-2).

**Haeger Till Member**—The Haeger Till Member of the Wedron Formation (Willman and Frye, 1970, p. 69) is named for Haegers Bend, a village on the Fox River in McHenry County, and the type section is in roadcuts half a mile northwest of the village (NW NE 23, 43N-8E). In the type exposure the Haeger Member consists of 12 feet of calcareous, gravelly, silty, yellow-gray till overlying the Yorkville Till Member and overlain by the Richland Loess. In some isolated hills the member may be as much as 50-100 feet thick, but it is generally thinner. It is overlain by the Wadsworth Till Member east of the area where the Yorkville is the surface drift. It occurs only in the northeastern part of the state (fig. Q-5).

**Wadsworth Till Member**—The Wadsworth Till Member of the Wedron Formation (Willman and Frye, 1970, p. 70) is named for Wadsworth, Lake County, and the type section is in roadcuts at the intersection of Illinois Highway 131 and Wadsworth Road (SE SE SW 30, 46N-12E). The member consists of the clayey gray tills of the Lake Border Morainic System, the Tinley Moraine, and much of the Valparaiso Morainic System. The member occurs above the Haeger and Yorkville Till Members, and it is overlain by very thin Richland Loess. It is the youngest till member of the Wedron Formation exposed in Illinois, and it is marginal to the Lake Michigan shore (fig. Q-5). It is also present under most of southern Lake Michigan, where it forms the floor of the lake east of Chicago. It is overlain by the Equality and Lake Michigan Formations in the center of the southern part of the lake.

**Oakland Till Member**—The Oakland Till Member of the Wedron Formation (Ford, in Johnson et al., 1972, p. 15) is named for Oakland, Coles County, where it is the surface drift, but it has been described only from its occurrence in the Harmattan strip mine in Vermilion County (NE NE NW 4, 19N-12W). In the Harmattan strip mine it ranges from 0 to more than 30 feet thick. It is a coarse, blocky, calcareous, brown till containing wood fragments and mollusk shells (dated at  $20,800 \pm 130$  radiocarbon years B.P.; sample ISGS-81). It locally contains thin beds of silt, sand, and gravel at the base. It occurs above Robein Silt and is overlain by the Glenburn Till Member.

**Glenburn Till Member**—The Glenburn Till Member of the Wedron Formation (Johnson et al., 1971, p. 202) is named for Glenburn, Vermilion County, and the type section is in the Emerald Pond Section (NE SW SW 33, 20N-12W) (Johnson et al., 1972, p. 42). In the type section it is 17 feet thick and consists of pinkish brown to dark brown, calcareous, somewhat sandy till. At the type section it occurs above the Banner Formation of Kansan age and it is overlain by the Batestown Till Member of the Wedron Formation, but elsewhere in Vermilion and adjacent counties it has been described as overlying the Robein Silt and the Oakland Till Member of the Wedron Formation. It occurs in central eastern Illinois.

**Batestown Till Member**—The Batestown Till Member of the Wedron Formation (Johnson et al., 1971, p. 202) is named for Batestown, Vermilion County, and the type section is in the Emerald Pond Section (NE SW SW 33, 20N-12W) (Johnson et al., 1972, p. 42). In the type section the Bates-town is 14 feet thick and consists of light olive brown to dark gray, calcareous, sandy to silty till that contains beds of sand and silt and one bed of boulders. The Batestown is bounded by the Glenburn Till Member below and the Snider Till Member above, or, where the Snider is absent, by the Richland Loess. The member occurs in central eastern Illinois (fig. Q-5).

**Snider Till Member**—The Snider Till Member of the Wedron Formation (Johnson et al., 1971, p. 204) is named for Snider, Vermilion County, and the type section is in the Emerald Pond Section (NE SW SW 33, 20N-12W) (Johnson et al., 1972, p. 42). In the type section the member is 16 feet thick and consists of light olive-brown to gray-brown, calcareous, blocky, jointed, clayey till and a basal zone of silt, sand, and gravel. It occurs in central eastern Illinois (fig. Q-5), where it overlies the Batestown Till Member and is commonly overlain by thin Richland Loess. The uppermost part of the Snider Till is leached and within the B-horizon of the Modern Soil.

## Richland Loess

The Richland Loess (Frye and Willman, 1960, p. 7) is named for Richland Creek, Woodford County, and the type section is in a roadcut north of the creek (NW SE SW 11, 28N-3W). The formation is massive tan silt that is calcareous below the leached zone of the Modern Soil and is locally fossiliferous (Leonard and Frye, 1960). It is as much as 20 feet thick on the east bluff of the Illinois Valley north of Peoria, but it thins to 1-2 feet in the Chicago area. This loess was formerly called Tazewell loess (Leighton, 1933). It rests on deposits of the Wedron, Henry, and Equality Formations inside the area of Woodfordian glaciation (fig. Q-1A), and it is terminated upward by the Modern Soil. It is not differentiated outside that area, but it is continuous with the upper part of the Peoria Loess (fig. Q-8).

## Jules Soil

The Jules Soil (Willman and Frye, 1970, p. 88) is named for Jules, Cass County, and the type section is in the Jules Section (SE SE NE 13, 18N-11W) (Frye et al., 1968a, p. 21). This soil is solum an immature, or A-C, profile with a dark gray solum that lacks a textural B-horizon. It occurs within the Peoria Loess and at a few places within the Richland Loess, but only in the thick loess sequences near the Illinois River Valley of central Illinois. It represents an interruption in loess deposition between the deposition of the Tiskilwa and Malden Till Members of the Wedron Formation (Frye et al., 1974b).

## Twocreekan Substage

The Twocreekan Substage (Frye and Willman, 1960, p. 8) is named for Two Creeks, Manitowoc County, Wisconsin, and the type section is in the Two Creeks Section, 2 miles east of the town in the bluff of Lake Michi-

gan (Thwaites and Bertrand, 1957, p. 859-864; Frye et al., 1965, p. 57). At the type locality, lake deposits of silt and sand and the forest bed overlies till and, in turn, are overlain by till. Many radiocarbon dates have been obtained from wood of the forest bed in the upper part of the Two Creeks deposits (Black and Rubin, 1968), and the time span for the substage is from 12,500 to 11,000 radiocarbon years B.P. Deposits of the Two-creek Substage have not been specifically differentiated in Illinois, although they occur in the Equality Formation sediments of Lake Chicago and other glacial lakes and in the various surficial formations that are dominant-ly of Holocene age.

### *Valderan Substage*

The Valderan Substage (Thwaites, 1943; Frye and Willman, 1960, p. 9) is named for Valders, Manitowoc County, Wisconsin, and the type section was designated as the drift in a quarry at Valders (Thwaites and Bertrand, 1957, p. 864-866). The base of the substage is defined (Frye et al., 1968b, p. E18) as the contact of the Valders till on the Two Creeks forest bed at the Two Creeks Section, eastern Wisconsin, and the top is defined as the top of the Cochrane till below post-Cochrane deposits in the James Bay Lowland of Ontario, Canada (Hughes, 1956)—a time span from 11,000 to 7,000 radiocarbon years B.P. Recent studies (Evenson, 1973) suggested that the till in the quarry at Valders is equivalent to the till beneath the Two Creeks forest bed and is therefore Woodfordian in age. If that finding is confirmed, the Two Creeks exposure, the type section of the Twocreek Substage, should preferably be designated as the reference section for the Valderan Substage as well. The name "Valderan Substage," now well established for the drift younger than Twocreek, as clearly intended by Thwaites (1943), Leighton (1957), and others, can then be retained. The rock-stratigraphic name for the post-Twocreek till in eastern Wisconsin may conveniently be changed from Valders till to Two Rivers Till, as proposed by Evenson (1973) and Lineback et al. (1974). In Illinois, deposits of the Valderan Substage occur in the Equality Formation, particularly in the deposits of Lake Algonquin in the Lake Michigan Basin, in the Henry Formation along the Mississippi Valley, and in the various surficial formations that are dominantly of Holocene age.

## **Holocene Stage**

The Holocene Stage, although based on a term and a concept that developed more than a century ago, has never been properly defined as a time-stratigraphic unit. It has been accepted as a replacement for "Recent" by the U. S. Geological Survey (Cohee, 1968) but without formal stratigraphic definition. For formal use in Illinois, Holocene Stage has replaced Recent Stage as the youngest time-stratigraphic subdivision of the Pleistocene Series (Willman and Frye, 1970, p. 126). In that sense it is defined as embracing all deposits younger than the top of the Wisconsin Stage. The Holocene Age, therefore, extends from approximately 7000 radiocarbon years B.P. to the present. Six formations in Illinois are dominantly of Holocene age, but in many localities these surficial deposits began to accumulate and the Modern Soil began to develop as soon as the glaciers melted from the area; consequently, the lower parts of the deposits are Wisconsinan in age (fig. Q-4). These deposits are generally overlain only by the Modern Soil developed in their tops, but along marginal areas there is some overlapping and intertonguing. To avoid repetition of a formation in a single section or the occurrence of formations in different orders, each surficial formation can be overlain only by the surficial formations that are specified in the description given for that formation. The order is based on the most common relations. In complex relations the formations are terminated laterally by a vertical cut-off. Holocene deposits are abundant throughout Illinois.

### *Cahokia Alluvium*

The Cahokia Alluvium (Willman and Frye, 1970, p. 75) is named for Cahokia, St. Clair County, which is located on the floodplain of the Mississippi River, and the type section is in a boring drilled 3 miles southwest of Cahokia (4300 feet south of lat. 38°32'30" N and 5200 feet east of long. 90°15' W) (Bergstrom and Walker, 1956, test hole No. 2). In the boring, the Cahokia consists of 45 feet of silt, clay, and silty sand, overlying 60 feet of sand and gravel of the Henry Formation, which rests on bedrock. The Cahokia Alluvium includes the deposits in the floodplains and channels of present rivers and streams, and the name replaces the long-used informal term "Recent Alluvium." Although largely of Holocene age, the formation in many places probably contains some deposits as old as Woodfordian. It consists mainly of poorly sorted silt, clay, and silty sand but locally contains lenses of sand and gravel. Its thickness varies greatly but rarely exceeds 50 feet. The formation rests on rocks of many ages. It generally is terminated upward by the surface of the floodplain and the Modern Soil, but locally it is overlain by the Parkland Sand, the Grayslake

Peat, the Lacon Formation, or the Peyton Colluvium. The Cahokia Alluvium occurs throughout Illinois in valley bottoms (fig. 11),

### *Parkland Sand*

The Parkland Sand (Willman and Frye, 1970, p. 78) is named for Parkland, Tazewell County, and the type section is in a roadcut 5 miles west of Parkland (SW SE SW 2, 23N-7W). The formation consists of windblown sand in dunes and sheet-like deposits. The thickness ranges sharply—some dunes reach 100 feet high—but the range is commonly 20-40 feet. The Parkland Sand is a surficial deposit, but it is locally overlain by the Richland Loess, the Peyton Colluvium, or the Lacon Formation. It occurs in large areas along the Illinois River Valley of central Illinois, the Green River Lowland and the Mississippi Valley of northwestern Illinois, the Kankakee Valley in northeastern Illinois, and in smaller areas elsewhere.

### *Grayslake Peat*

The Grayslake Peat (Willman and Frye, 1970, p. 77) is named for Grayslake, Lake County, and the type section is in a pit 1 mile southeast of Grayslake (NE SE NE 2, 44N-10E), where 14 feet of peat is exposed (Hester and Lamar, 1969). The formation consists of peat, sandy and silty peat, muck rich in organic material, and a foot or two of silt at the top. In some places it contains beds of marl, silt, and clay. It rarely exceeds 20 feet thick. Although it is a surficial formation, it is locally overlain by the Cahokia Alluvium, the Parkland Sand, the Peyton Colluvium, or the Lacon Formation. It occurs as a filling of ponds and poorly drained areas, principally in the region of Wisconsinan glaciation, and in the bottomlands of the major valleys.

### *Lacon Formation*

The Lacon Formation (Willman and Frye, 1970, p. 77) is named for Lacon, Marshall County, and the type locality is a landslip area along the bluffs of the Illinois River Valley, 2 miles northwest of Lacon (E1/2 2, 12N-9E) (Ekblaw, 1932). The formation consists of gravity-initiated deposits, such as landslides, slumps, slips, and rock falls, most of which are triggered by seasonal increases in pore-water pressure and move over surfaces lubricated by infiltrated water. The material is unsorted and reflects a local source. It is a surficial formation, and where it locally interfingers with the Cahokia Alluvium and the Peyton Colluvium it is considered part of those formations. It occurs in the many parts of the state where valley bluffs are prominent.

### *Peyton Colluvium*

The Peyton Colluvium (Willman and Frye, 1970, p. 79) is named for Peyton Creek, Peoria County, and the type section is along the creek at the base of the Illinois Valley bluffs, 1.5 miles southwest of Glasford (NW NE 32, 7N-6E). The locality is mapped as slopewash and alluvial fans (Wanless, 1957). The formation includes the widely distributed but narrow belts of poorly sorted debris that have accumulated on the lower slopes and at the base of slopes by processes of creep, slopewash, and mudflow. The many small cones and fans that occur at the mouths of gullies and rest on floodplain or terrace sur-

faces, generally interfingering with colluvium, are included in the formation. The Peyton is a surficial formation and is not overlain by other formations. Where it inter-tongues with the Cahokia Alluvium it is included in that formation.

### *Lake Michigan Formation*

The Lake Michigan Formation (Willman and Frye, 1970, p. 78), named for Lake Michigan, consists of the surficial lacustrine and beach deposits of the southern part of the lake. A cross section of the lake sediments along a line 12-32 miles east of Waukegan, Lake County, is the type locality (Gross et al., 1970). The formation also includes the deposits in the basins of other natural lakes in Illinois. It overlies Paleozoic rocks, glacial deposits of Wisconsinan age, or the Equality Formation, and it is overlain only by water or, on the beaches, by air. The sediments of the Lake Michigan Formation in the southern part of the lake have been described (Gross et al., 1970; Lineback et al., 1970, 1972; Lineback and Gross, 1972), and the chemical composition and trace element content of the sediments have been analyzed (Shimp et al., 1970, 1971; Ruch et al., 1970; Schleicher and Kuhn, 1970; Kennedy et al., 1971; Frye and Shimp, 1973). The formation attains a maximum thickness of more than 60 feet, but generally it is less than 40 feet thick. It is composed of clay, silt, a small proportion of sand, and local accumulations of organic matter. Seven members have been differentiated in the formation (fig. Q-4), all but one (Ravinia) of which have been defined from cores taken from the southern part of Lake Michigan.

**South Haven Member**—The South Haven Member of the Lake Michigan Formation (Lineback et al., 1970, p. 11) is named for South Haven, Ottawa County, Michigan, and the type section is the interval from 219.3 cm to the base of core 143 (lat. 42°21.8' N, long. 78°10.8' W, at a water depth of 390 feet). It is the lowest member of the formation and consists of reddish gray clay, generally less than 3.5 feet thick, on the east side of the lake. The member rests on the Wedron Formation, Equality Formation, or bedrock.

**Sheboygan Member**—The Sheboygan Member of the Lake Michigan Formation (Lineback et al., 1970, p. 11) is named for Sheboygan, Sheboygan County, Wisconsin, and the type section is the interval 112-219.3 cm in core 143, the same core as the type of the South Haven Member. The member consists of two reddish brown to brown clay units separated by a thin, persistent layer of gray clay. The member ranges up to 4 feet thick, is overlain by the Winnetka Member, and rests on the South Haven Member or the Equality Formation. Its maximum development is in the mid-lake area and it occurs only where water depth exceeds 230 feet. It thins shoreward to the east, south, and west. It is absent from the southwestern part of the lake.

**Wilmette Bed**—The Wilmette Bed of the Sheboygan Member of the Lake Michigan Formation (Lineback et al., 1970, p. 11) is named for Wilmette, Cook County, and the type section is in the type section of the Sheboygan Member. It is a bed of gray clay, with some silt and sand, in the middle of the Sheboygan Member. It is 3-9 inches thick, and it occurs only in the area of southern Lake Michigan where water depth exceeds 270 feet.

**Winnetka Member**—The Winnetka Member of the Lake Michigan Formation (Lineback et al., 1970, p. 8) is named for Winnetka, Cook County, and the type section is the interval 35.5-112 cm in core 143, the same core as the type of the South Haven Member. The member consists of brownish gray clay with a few interspersed black beds. It becomes somewhat sandy near the shore, but generally it is finer grained

than the overlying members. It is 1-6 feet thick. It rests on the South Haven and Sheboygan Members and the Equality Formation, and it is overlain by the Lake Forest and Waukegan Members. The Winnetka is absent where the Wedron or Equality Formations are near the sediment surface.

**Lake Forest Member**—The Lake Forest Member of the Lake Michigan Formation (Lineback et al., 1970, p. 8) is named for Lake Forest, Lake County, and the type section is the interval 16-35.5 cm in core 143, the same core as the type of the South Haven Member. The member is dark gray silty clay that usually contains many thin beds of black clay. The black beds contain more organic matter than the enclosing deposits and have been radiocarbon dated at  $6920 \pm 200$  radiocarbon years B.P. (sample ISGS-33) and  $7050 \pm 200$  radiocarbon years B.P. (sample ISGS-36). The member is generally siltier than the Winnetka and Sheboygan Members below and less sandy and more compact than the Waukegan Member above. It is 0-4 feet thick. It is present on the western and southern sides of southern Lake Michigan but is absent from the central and eastern areas.

**Waukegan Member**—The Waukegan Member of the Lake Michigan Formation (Lineback et al., 1970, p. 6) is named for Waukegan, Lake County, and the type section is the interval 0-16 cm in core 143, the same core as the type of the South Haven Member. It is the surficial sediment of the formation in large areas in the center and along the eastern side of southern Lake Michigan. It is distributed widely over the offshore lake floor except at a few places where bedrock or till form the lake bottom. It consists of soft sandy silt, silty clay with a high water content, sand, and gravel. It is 0.1-30 feet thick. The member becomes sandier near shore and in the southwestern part of the lake. A gray silt facies occurs on the east side of the lake where the member is thickest, and a brown silt facies is on the west side where the member thins to less than a foot thick (Lineback and Gross, 1972).

**Ravinia Sand Member**—The Ravinia Sand Member of the Lake Michigan Formation (Willman and Frye, 1970, p. 78) is named for Ravinia, in the southern part of Highland Park, Lake County, where the type exposure is an accessible section of the Lake Michigan beach (W1/2 31, 43N-13E). It consists of well sorted, largely medium-grained, nearly white beach sand containing local lenses of gravel. It is relatively clean, except for man-made litter and driftwood. Smaller areas of beach sand present along the shores of other natural lakes in Illinois are included in the Ravinia. The Ravinia Member includes only beach sand and is separated from the rest of the formation at the base of the low-water swash zone. Sands occurring offshore are included in the Waukegan Member. The character of the beach sands and adjacent deposits in extreme northeastern Illinois and the history of their development have been described by Hester and Fraser (1973).

### Modern Soil

As a soil-stratigraphic unit, the term "Modern Soil" (Willman and Frye, 1970, p. 89) is applied to any soil profile genetically related to the present topographic surface. It underlies the surface of most of Illinois. The soil ranges from very shallow to several feet in depth and is developed in any sediment that immediately underlies the existing land surface. The type section is the uppermost five units in the Buda East Section in Bureau County (SE SE SW 31, 16N-8E) (Frye et al., 1968a, p. 20). The term carries no implication of soil type in the soil science classification.

### Morphostratigraphy

The morphostratigraphic units called drifts, which are based on glacial moraines, are de-

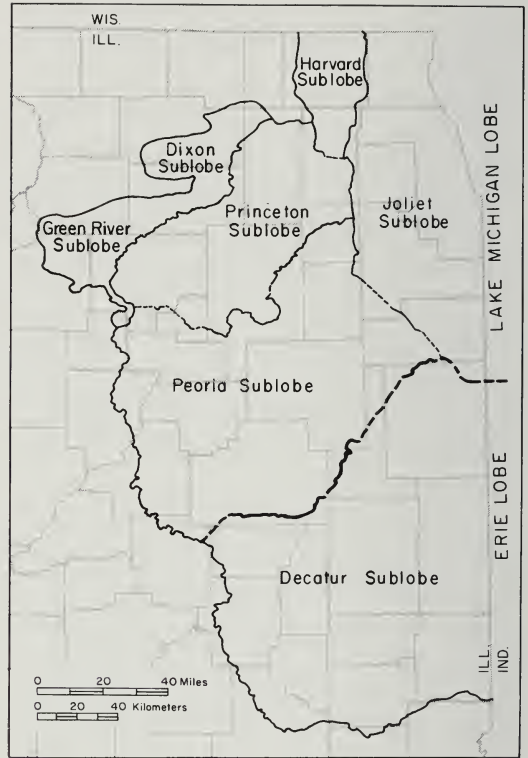


Fig. Q-9—Woodfordian lobes and sublobes in Illinois (Willman and Frye, 1970).

scribed for each of the glacial lobes (fig. Q-9). A few moraines are continuous from one lobe into another, and a unit is described in the lobe where it is first mentioned. The extent of the named moraines of the Wisconsin Stage is shown in figure Q-10. The Illinoian moraines and ridged drift areas are shown in figure Q-2. The fact that the drift is based on the moraine is not repeated in the description of each drift. The original namer of the moraine is cited as the namer of the drift. Alluvial terraces are classified as informal morphostratigraphic units. Those named were listed by Willman and Frye (1970).

### ERIE LOBE

Drift deposited by glaciers that invaded Illinois from the east is assigned to the Erie Lobe (fig. Q-9), although the lobe probably includes contributions by ice from the Lake Huron and Saginaw Lobes, which merged with the Erie Lobe. Erie Lobe glaciers ad-

vanced into Illinois during the Kansan, Illinoian, and Wisconsinan Stages, and their drifts are characterized in general by larger amounts of garnet than epidote, by dominance of illite, by the presence of both kaolinite and chlorite, and by more calcite than dolomite. In the Erie Lobe, morphostratigraphic units are differentiated only in the Wisconsinan Stage and are part of the Decatur Sublobe.

## Decatur Sublobe Drifts

The Decatur Sublobe drifts are related to two morainic systems and 22 named moraines (figs. Q-9, Q-10). The drift is divided into the Oakland, Glenburn, Batestown, and Snider Till Members of the Wedron Formation.

**Shelbyville Drifts** (Leverett, 1897, p. 17)—The Shelbyville Morainic System is named for Shelbyville, Shelby County. The drift is the outer and oldest Woodfordian drift in both the Decatur and Peoria Sublobes. The massive morainic system represents successive deposits of a fluctuating ice front that in the eastern part of the Decatur Sublobe produced three closely related moraines—Westfield, Nevins, and Paris. The morainic system extends west from the Indiana state line and then northwest about 200 miles to Peoria. In the Decatur Sublobe the drift consists of pinkish gray till of the Glenburn Till Member. In the Peoria Sublobe it is gray till that, with the Le Roy Drift, forms the Delavan Till Member of the Wedron Formation, and it is generally readily distinguishable from the overlying pink till of the Tiskilwa Till Member.

**Westfield Drift** (Willman and Frye, 1970, p. 92)—The Westfield Moraine, named for Westfield, Clark County, is the outermost moraine of the Shelbyville Morainic System and is traced for about 40 miles.

**Nevins Drift** (Willman and Frye, 1970, p. 92)—The Nevins Moraine, named for Nevins, Edgar County, the middle moraine of the Shelbyville Morainic System, is separated from the other moraines by narrow depressions and is traced for about 40 miles.

**Paris Drift** (Willman and Frye, 1970, p. 92)—The Paris Moraine, named for Paris, Edgar County, is the inner moraine of the Shelbyville Morainic System. It is traced from near the Indiana state line westward for about 50 miles.

**Heyworth Drift** (Willman and Frye, 1970, p. 92)—The Heyworth Moraine is named for Heyworth, McLean County. It is a weakly morainic area east and north from Clinton. In shape and orientation it differs from other Woodfordian moraines, and it may be an Illinoian moraine mantled with Woodfordian drift.

**Turpin Drift** (Willman and Frye, 1970, p. 92)—The Turpin Moraine is named for Turpin, Macon County. The moraine is a sharp ridge that extends only about 6 miles from Turpin northeast to the front of the Cerro Gordo Moraine. Because its orientation is parallel to Illinoian ridges and normal to the Woodfordian moraines, it, like the Heyworth, may be a mantled Illinoian ridge.

**Cerro Gordo Drift** (Leverett, 1899, p. 218)—The Cerro Gordo Moraine, named for Cerro Gordo, Piatt County, is a strongly lobate ridge extending for about 80 miles. It probably represents a major readvance of the ice front.

**Arcola Drift** (Leighton and Brophy, 1961, fig. 1)—The Arcola Moraine, named for Arcola, Douglas County, extends for about 50 miles and forms two well defined lobes. The western lobe once enclosed a large lake called Lake Douglas.

**Pesotum Drift** (Leighton and Brophy, 1961, fig. 1)—The Pesotum Moraine, named for Pesotum, Champaign County, is

a relatively weak ridge, in part flat-topped, that is traced for about 25 miles.

**West Ridge Drift** (Leverett, 1899, p. 223)—The West Ridge Moraine, named for West Ridge, a small village 3 miles southwest of Villa Grove, Douglas County, extends for about 50 miles.

**Hildreth Drift** (Willman and Frye, 1970, p. 94)—The Hildreth Moraine, named for Hildreth, Edgar County, extends from the Indiana state line westward for about 25 miles.

**Ridge Farm Drift** (Willman and Frye, 1970, p. 94)—The Ridge Farm Moraine, named for the town of Ridge Farm, Vermilion County, extends westward from the Indiana state line for about 25 miles.

**Champaign Drift** (Leverett, 1897, p. 18)—The Champaign Moraine, named for Champaign, Champaign County, was originally called the Champaign Morainic System and included the Pesotum, Hildreth, Ridge Farm, and Urbana Moraines. As those drifts have overlapping relations, they are now considered separate moraines (Willman and Frye, 1970). The Champaign Moraine is restricted to the ridge extending from Champaign to the Bloomington Morainic System, about 30 miles.

**Rantoul Drift** (Willman and Frye, 1970, p. 94)—The Rantoul Moraine, named for Rantoul, Champaign County, is a broad morainic ridge extending 15 miles southwest from the Newtown Moraine to the Champaign Moraine. Because of its alignment on the trends of earlier Woodfordian moraines, it may be a buried moraine mantled with Champaign Drift.

**Urbana Drift** (Ekblaw, 1941)—The Urbana Moraine, named for Urbana, Champaign County, extends from Rantoul through Urbana to the Indiana state line, about 50 miles.

**Illiana Drifts** (Willman and Frye, 1970, p. 95)—The Illiana Morainic System, formerly considered part of the Bloomington Morainic System, is named for Illiana, Vermilion County, on the Illinois-Indiana state line. The system consists of two closely parallel moraines differentiated as the Newtown and Gifford Moraines, and it extends eastward from the Gibson City interlobate area about 50 miles to the state line.

**Newtown Drift** (Willman and Frye, 1970, p. 95)—The Newtown Moraine, named for Newtown, Vermilion County, is the frontal moraine of the Illiana Morainic System.

**Gifford Drift** (Leighton and Brophy, 1961, p. 95)—The Gifford Moraine, named for Gifford, Champaign County, is the inner and higher moraine of the Illiana Morainic System.

**Paxton Drift** (Willman and Frye, 1970, p. 95)—The Paxton Moraine, named for Paxton, Ford County, extends eastward across the Decatur Sublobe from the Gibson City reentrant to the Indiana state line, about 55 miles. It previously was considered the frontal moraine of the discontinued Chatsworth Morainic System.

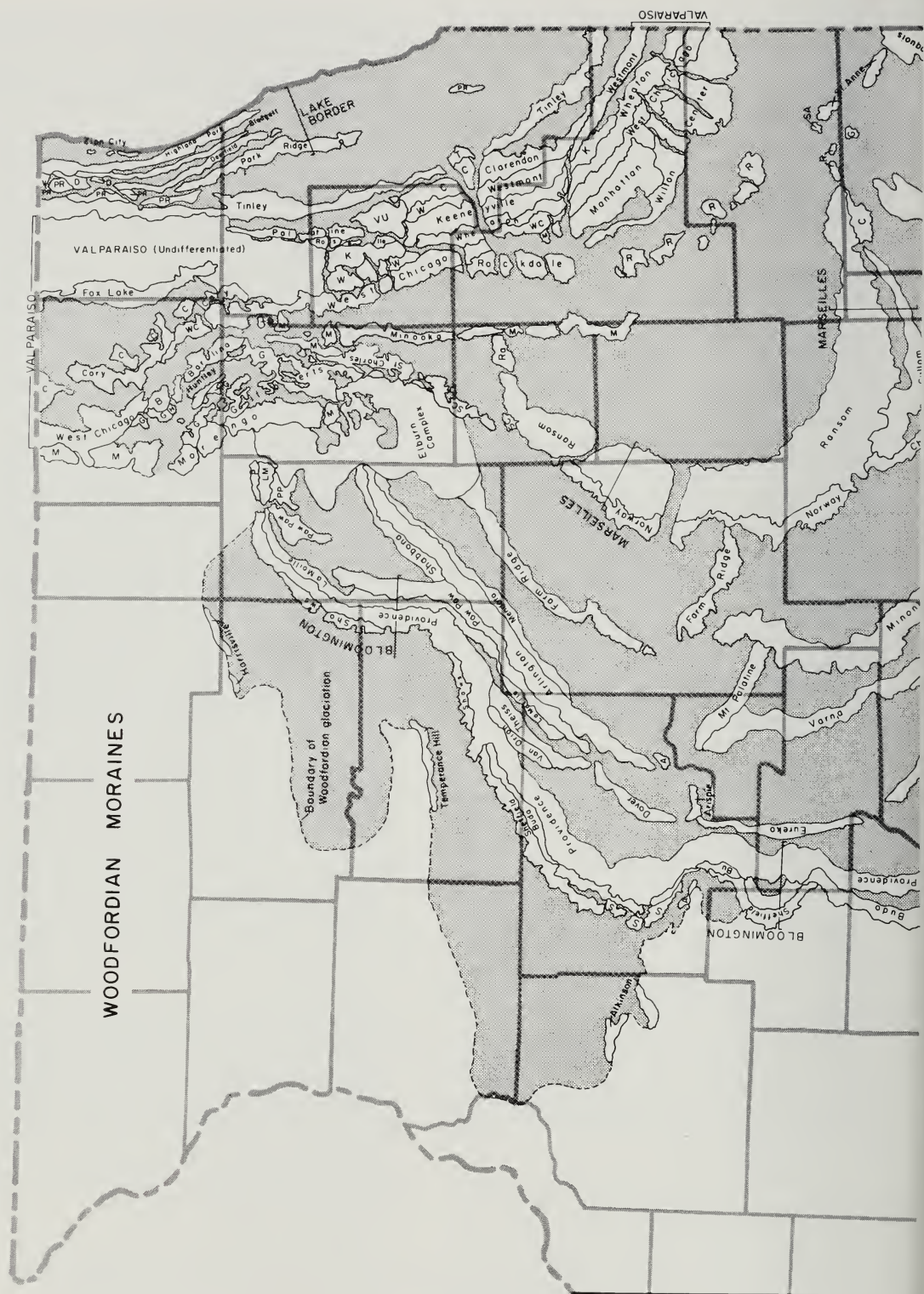
**Ellis Drift** (Willman and Frye, 1970, p. 96)—The Ellis Moraine, named for Ellis, Vermilion County, was formerly classified as part of the Chatsworth Morainic System. It is a relatively weak moraine but is traced for about 45 miles.

**Chatsworth Drift** (Leverett, 1899, p. 259)—The Chatsworth Moraine, named for Chatsworth, Livingston County, is a prominent moraine 75 miles long with strong relief. It occurs in both the Decatur and Peoria Sublobes.

**Gilman Drift** (Willman and Frye, 1970, p. 96)—The Gilman Moraine, named for Gilman, Iroquois County, is a broad but weak lobate ridge about 40 miles long, partially covered by the deposits of glacial Lake Watseka.

**St. Anne Drift** (Willman and Frye, 1970, p. 96)—The St. Anne Moraine, named for St. Anne, Kankakee County, is a weak morainic ridge extending only about 15 miles from Mt. Langham, a large kame, to the Iroquois Moraine.

**Iroquois Drift** (Leverett, 1899, p. 258, 336)—The Iroquois Moraine, named for Iroquois County, is the youngest deposit of the Erie Lobe, though possibly a contribution of





the Saginaw Lobe, in Illinois. It is the deposit of a glacier that invaded Illinois from the east for about 8 miles along a 15-mile front.

## LAKE MICHIGAN LOBE

Drift deposited by glaciers that followed the Lake Michigan Basin and spread westward and southwestward across Illinois is referred to the Lake Michigan Lobe (fig. Q-9). Morphostratigraphic units are differentiated in the Lake Michigan Lobe drifts of Illinoian and Wisconsinan age. Moraines are widely spaced and discontinuous in the Illinoian drift (fig. Q-2), but are locally useful in morphostratigraphic classification. In the Wisconsinan Woodfordian drift, the moraines are more useful in classification because of their continuity (fig. Q-10) and because many represent readvances of the ice front that produced layered sequences in the drift. After the Woodfordian ice overflowed the Lake Michigan Basin, it was diverted by topographic irregularities and contact with the Erie Lobe glaciers into several sublobes that controlled the distribution of the moraines deposited during the fluctuating withdrawal of the ice front. The major groups of nearly parallel moraines are differentiated as the Peoria, Green River, Dixon, Princeton, Harvard, and Joliet Sublobes. The drift consists of tills and interlayered water-laid deposits that, in the rock-stratigraphic classification, are assigned to the Wedron Formation and divided into eight members on the basis of differences in till composition (fig. Q-5).

### Illinoian Drifts

**Mendon Drift** (Leighton and Brophy, 1961, pl. 1, p. 15; Frye et al., 1964, p. 14)—The Mendon Moraine, named for Mendon, Adams County, marks the outer limit of the Illinoian drift of the Lake Michigan Lobe. It extends from the Mississippi River Valley near Warsaw to the Illinois River Valley at Pearl, about 90 miles. South of Pearl it is absent along the Illinois Valley for many miles, but it is probably represented by morainic topography in Jersey County north of the confluence of the Illinois and Mississippi Rivers. However, that area may also include an extension of the Table Grove Moraine. The Mendon Drift is largely the Kellerville Till Member of the Glasford Formation.

**Table Grove Drift** (Willman and Frye, 1970, p. 114)—The Table Grove Moraine, named for Table Grove, Fulton County, is a distinctly morainic ridge extending through the middle part of the area of Illinoian drift in western Illinois. Although continuous for about 75 miles, its continuation east of the Illinois Valley and north of southern Knox County is uncertain. It marks the front of the Hulick Till Member of the Glasford Formation.

**Oneida Drift** (Willman and Frye, 1970, p. 115)—The Oneida Moraine, named for Oneida, Knox County, is a weak morainic ridge traced for about 15 miles in Knox and Henry Counties.

**Williamsfield Drift** (Willman and Frye, 1970, p. 115)—The Williamsfield Moraine, named for Williamsfield, Knox County, is a weak morainic ridge that extends southward from Williamsfield for about 7 miles.

**Oak Hill Drift** (Willman and Frye, 1970, p. 115)—The Oak Hill Moraine, named for Oak Hill, Peoria County, is a continuous ridge extending northwest from the front of the Wisconsinan drift for about 20 miles. It may mark the front of a significant readvance because it is the outer limit of the Radnor Till Member of the Glasford Formation.

**Jacksonville Drift** (Ekblaw, in Ball, 1938, p. 219)—The Jacksonville Moraine, named for Jacksonville, Morgan County, is a discontinuous belt of morainic hills and crevasse deposits, without a well defined front, in Morgan and Montgomery Counties.

**Buffalo Hart Drift** (Leverett, 1899, p. 74-76)—The Buffalo Hart Moraine, named for Buffalo Hart, Sangamon County, is a broad area of morainic topography, crevasse deposits, and kames. It has the mineral composition of the Radnor Till and probably correlates with the Oak Hill Moraine west of the Illinois Valley.

## Wisconsinan (Woodfordian) Drifts

### Peoria Sublobe Drifts

The Peoria Sublobe drifts include three morainic systems and 20 individual moraines (figs. Q-9, Q-10). The outermost moraine is part of the Shelbyville Morainic System, already described as being largely in the Erie Lobe, which extends northward in the Peoria Sublobe to Peoria.

**Le Roy Drift** (Ekblaw, 1941)—The Le Roy Moraine, named for Le Roy, McLean County, is a lobate ridge that is traced for about 70 miles and may represent a significant readvance of the ice that was probably equivalent to the strongly lobate readvance of the Decatur Sublobe glacier that deposited the Cerro Gordo Moraine.

**Shirley Drift** (Willman and Frye, 1970, p. 98)—The Shirley Moraine, named for Shirley, McLean County, is a minor moraine about 25 miles long.

**Kings Mill Drift** (Willman and Frye, 1970, p. 98)—The Kings Mill Moraine, named for Kings Mill Creek in McLean County, is a weak morainic ridge extending for only 10 miles near the front of the Bloomington Morainic System.

**Bloomington Drifts** (Leverett, 1897, p. 19)—The Bloomington Morainic System, named for Bloomington, McLean County, is one of the most prominent morainic features of the Lake Michigan Lobe drift and it forms the front of the Peoria, Princeton, and Harvard Sublobes. The major part of the drift is the pink till of the Tiskilwa Member of the Wedron Formation, which distinguishes it from the older gray tills and the younger yellow-tan tills of Woodfordian age. North of Peoria the system consists of three well defined moraines, but in other places only one or two crests are recognizable. Five ridges are named in the Peoria Sublobe—the Washington, Metamora, Sheffield, Buda, and Providence Moraines.

**Washington Drift** (Willman and Frye, 1970, p. 99)—The Washington Moraine, named for Washington, Tazewell County, is a minor morainic area back of the main ridge of the Bloomington Morainic System and can be traced for about 10 miles in the southern part of the Peoria Sublobe.

**Metamora Drift** (Ekblaw, 1941)—The Metamora Moraine, named for Metamora, Woodford County, is a well defined ridge about 10 miles long that probably marks the eastern margin of a narrow lobe that extended into the Illinois River Valley during the final stages of the building of the Bloomington Morainic System.

**Sheffield Drift** (MacClintock and Willman, 1959, p. 23)—The Sheffield Moraine, named for Sheffield, Bureau County, is the outermost moraine of the Bloomington Morainic System in the Peoria Sublobe and in the southern part of the Princeton Sublobe. It is about 60 miles long.

**Buda Drift** (MacClintock and Willman, 1959, p. 23)—The Buda Moraine, named for Buda, Bureau County, is a prominent morainic ridge about 65 miles long that extends from Peoria northward into the Princeton Sublobe. It generally is the middle ridge of the Bloomington Morainic System.

**Providence Drift** (MacClintock and Willman, 1959, p. 24)—The Providence Moraine, named for Providence, Bureau County, forms the crest of the Bloomington Morainic System and rises as much as 200 feet above the frontal outwash plain. In many areas it has a very rough knob and kettle topography. It is traced from Peoria northeastward for about 125 miles in the Peoria and Princeton Sublobes. It is probably equivalent to the Metamora Moraine east of the Illinois Valley.

**Normal Drift** (Leighton and Ekblaw, 1932, p. 13)—The Normal Moraine, named for Normal, McLean County, is the first moraine back of the Bloomington Morainic System. It is traced for about 35 miles in the southern part of the Peoria Sublobe, in which area it is the front of the gray to tan silty till differentiated as the Malden Till Member of the Wedron Formation.

**Eureka Drift** (Willman and Frye, 1970, p. 100)—The Eureka Moraine, named for Eureka, Woodford County, extends for about 100 miles, entirely across the Peoria Sublobe. It formerly was correlated with the Normal Moraine, but it overlaps the Normal and forms the front of the Malden Till Member.

**Fletchers Drift** (Willman and Frye, 1970, p. 100)—The Fletchers Moraine, named for Fletchers, a railroad siding 3 miles southwest of Cooksville, McLean County, also was formerly included in the Normal Moraine. It has a well defined front and is traced westward from the Gibson City reentrant for about 20 miles.

**El Paso Drift** (Leighton and Brophy, 1961, fig. 1)—The El Paso Moraine, named for El Paso, Woodford County, previously considered the frontal ridge of the discontinued Cropsey Morainic System, is traced westward from the Gibson City reentrant for about 45 miles.

**Varna Drift** (Willman and Frye, 1970, p. 100)—The Varna Moraine, named for Varna, Marshall County, was previously part of the discontinued Cropsey Morainic System. The Varna is traced for 40 miles but is eroded at the Illinois River Valley.

**Minonk Drift** (Willman and Frye, 1970, p. 101)—The Minonk Moraine, named for Minonk, Woodford County, was previously part of the discontinued Cropsey Morainic System. It extends for 65 miles, entirely across the Peoria Sublobe.

**Strawn Drift** (Willman and Frye, 1970, p. 101)—The Strawn Moraine, named for Strawn, Livingston County, is a weak morainic ridge between the Minonk and Chatsworth Moraines and was previously included in the discontinued Cropsey Morainic System. It is traced for only about 15 miles.

**Marseilles Drifts** (Leverett, 1897, p. 20)—The Marseilles Morainic System, named for Marseilles, La Salle County, is a massive ridge that generally exhibits a distinct lower frontal ridge. The frontal ridge is not continuous; the north part is named Norway and the south part Cullom. The higher, continuous crest is differentiated as the Ransom Moraine. The Ransom is largely greenish gray clayey till, which is part of the Yorkville Till Member of the Wedron Formation. It forms the innermost drift of the Peoria Sublobe and extends entirely across the sublobe.

**Norway Drift** (Willman and Frye, 1970, p. 102)—The Norway Moraine, named for Norway, La Salle County, extends for about 40 miles along the front of the northern part of the Marseilles Morainic System.

**Cullom Drift** (Leighton and Brophy, 1961, fig. 1)—The Cullom Moraine, named for Cullom, Livingston County, occupies a position similar to that of the Norway Moraine for about 35 miles along the southern part of the Marseilles Morainic System.

**Ransom Drift** (Willman and Frye, 1970, p. 102)—The Ransom Moraine, named for Ransom, La Salle County, forms the main crest of the Marseilles Morainic System and is traced for about 100 miles.

## Green River and Dixon Sublobes Drifts

Because of their position outside the Bloomington Morainic System, the drifts of the Green River and Dixon Sublobes (figs. Q-9, Q-10) are probably equivalent to the Shelbyville Drift in the Decatur and Peoria Sublobes. The Woodfordian drift is thin, and only three areas of morainic topography along the margins of the sublobes are named.

**Temperance Hill Drift** (Willman and Frye, 1970, p. 103)—The Temperance Hill Moraine, named for Temperance Hill School, 3 miles northwest of Lee Center, Lee County, is a ridge traced for about 12 miles along the northern side of the Green River Sublobe.

**Atkinson Drift** (Willman and Frye, 1970, p. 103)—The Atkinson Moraine, named for Atkinson, Henry County, consists of patches of morainic hills along the southern side of the Green River Sublobe.

**Harrisville Drift** (Willman and Frye, 1970, p. 102)—The Harrisville Moraine, named for Harrisville, Winnebago County, extends for about 10 miles along the north side of the Dixon Sublobe.

## Princeton Sublobe Drifts

The Princeton Sublobe (figs. Q-9, Q-10) includes one morainic system, 16 named moraines, and one complex—an area with variously oriented morainic ridges. The pink sandy till of the Tiskilwa Till Member of the Wedron Formation characterizes the outer part of the drift, followed successively eastward by the gray-tan silty till of the Malden Till Member and the gray clayey till of the Yorkville Till Member.

**Bloomington Drifts**—The southern moraines of the Bloomington Morainic System, the Sheffield, Buda, and Providence Moraines that were previously described for the Peoria Sublobe, extend northward into the Princeton Sublobe, but five other moraines are differentiated locally in the system in the Princeton Sublobe—the Shaws, Van Orin, Theiss, La Moille, and Paw Paw Moraines—all of which consist largely of the pink till of the Tiskilwa Till Member.

**Shaws Drift** (Willman and Frye, 1970, p. 105)—The Shaws Moraine, named for Shaws, Lee County, is the outermost ridge of the Bloomington Morainic System, occupying a position in the northern part of the sublobe similar to that of the Sheffield Moraine farther south. It has been traced for about 25 miles.

**Van Orin Drift** (Willman and Frye, 1970, p. 105)—The Van Orin Moraine, named for Van Orin, Bureau County, is a well defined ridge but is traced for only about 10 miles before it blends into the back slope of the Providence Moraine.

**Theiss Drift** (Willman and Frye, 1970, p. 105)—The Theiss Moraine, named for Theiss Cemetery, 3 miles southwest of Sublette, Lee County, is a distinct ridge for about 16 miles, but it, too, blends into the back slope of the Providence Moraine.

**La Moille Drift** (Willman and Frye, 1970, p. 105)—The La Moille Moraine, named for La Moille, Bureau County, is a narrow ridge that is traced for about 50 miles. In its southern part it separates from the Bloomington Morainic System.

**Paw Paw Drift** (Willman and Frye, 1970, p. 106)—The Paw Paw Moraine, named for Paw Paw, Lee County, is the inner moraine of the northern part of the Bloomington Morainic System and is traced for about 50 miles. It is a prominent moraine that, southward, separates from the Bloomington Morainic System, and in part of that area it has a thin overlapping cover of yellow-tan till of the Malden Till Member.

**Shabbona Drift** (Willman and Frye, 1970, p. 106)—The Shabbona Moraine, named for Shabbona, De Kalb County, is a weakly morainic area about 18 miles long that consists largely of a thin deposit of the Malden Till Member. It marks a major readvance of the ice front.

**Dover Drift** (Cady, 1919b, p. 24, 81)—The Dover Moraine, named for Dover, Bureau County, is traced for about 12 miles. It marks the front of the Malden Till Member and is probably equivalent to the Shabbona Moraine, but cannot be traced directly to it.

**Arispie Drift** (Willman and Frye, 1970, p. 106)—The Arispie Moraine, named for Arispie Township, Bureau County, is an east-west ridge only 4 miles long, eroded at the Illinois River Valley, but it probably is a connecting link between the Varna Moraine in the Peoria Sublobe and the Dover Moraine in the Princeton Sublobe.

**Arlington Drift** (Cady, 1919b, p. 24, 81)—The Arlington Moraine, named for Arlington, Bureau County, is a prominent moraine that is traced northeastward from the Illinois River Valley for 55 miles.

**Mt. Palatine Drift** (Leighton and Brophy, 1961, fig. 1)—The Mt. Palatine Moraine, named for Mt. Palatine, Putnam County, is a prominent ridge on the south side of the Princeton Sublobe, where it is traced for about 15 miles. It probably correlates with the Arlington Moraine on the north side of the lobe.

**Mendota Drift** (Willman and Frye, 1970, p. 107)—The Mendota Moraine, named for Mendota, La Salle County, is a weakly morainic ridge that can be traced on the back slope of the Arlington Moraine for about 40 miles.

**Farm Ridge Drift** (Leverett, 1899, p. 260)—The Farm Ridge Moraine is named for Farm Ridge, which is now called Grand Ridge, La Salle County. It has a lobate configuration and extends for 35 miles north of the Illinois River Valley and for 15 miles south of the valley.

**Elburn Drift** (Willman and Frye, 1970, p. 107)—The Elburn Complex, named for Elburn, Kane County, is an area of variously oriented morainic ridges, kames, eskers, and lake basins at the junction of the Princeton and Harvard Sublobes.

**St. Charles Drift** (Willman and Frye, 1970, p. 108)—The St. Charles Moraine, named for St. Charles, Kane County, is a weakly morainic area traced for 25 miles from the front of the Marseilles Morainic System to the northern part of the Minooka Moraine. It marks the front of the very clayey till characteristic of the Yorkville Till Member.

## Harvard Sublobe Drifts

The Harvard Sublobe (figs. Q-9, Q-10) includes six moraines that have a slightly westward bulge north of the Princeton Sublobe. They consist of the Tiskilwa, Malden, Yorkville, and Haeger Till Members of the Wedron Formation.

**Marengo Drift** (Leverett, 1899, p. 290)—The Marengo Moraine, named for Marengo, McHenry County, is a massive moraine that is largely pink till. It extends southward from the Wisconsin state line for about 40 miles, terminating at the Elburn Complex.

**Gilberts Drift** (Leighton and Ekblaw, 1932, p. 48)—The Gilberts Moraine, named for Gilberts, Kane County, is a low area about 30 miles long behind the Marengo Moraine and is largely pinkish gray till, gravel, and lacustrine sediments. It is assigned to the Malden Till Member, but it is pinker than the Malden in the Princeton Sublobe.

**Huntley Drift** (Leighton and Willman, 1953, p. 53)—The Huntley Moraine, named for Huntley, McHenry County, is a low, discontinuous ridge about 8 miles long that is largely till of the Yorkville Till Member.

**Barlina Drift** (Willman and Frye, 1970, p. 109)—The Barlina Moraine, named for Barlina Road, northwest of Lake-in-the-Hills, McHenry County, is a rough-surfaced ridge about 16 miles long, which, like the Huntley, consists largely of till of the Yorkville Till Member.

**Valparaiso Drifts** (Leverett, 1897, p. 26)—The Valparaiso Morainic System is largely in the Joliet Sublobe, but the West Chicago and Cary Moraines curve northwestward into the Harvard Sublobe, and the drifts are part of the Haeger Till Member.

## Joliet Sublobe Drifts

The Joliet Sublobe (figs. Q-9, Q-10) consists of the moraines that trend essentially parallel to the Lake Michigan shore. The lobe contains two morainic systems and 19 named moraines. The moraines in the northwest part of the lobe consist of the gravelly till of the Haeger Till Member, but the others are gray clayey till of the Yorkville and Wadsworth Till Members.

**Minooka Drift** (Leverett, 1897, p. 20)—The Minooka Moraine, named for Minooka, Grundy County, forms the outer edge of the Joliet Sublobe for about 50 miles. It ends at the head of Illinois River, where its southward extension was widely eroded by the Kankakee Flood. It is mainly the gray clayey till of the Yorkville Till Member.

**Rockdale Drift** (Fisher, 1925, p. 87)—The Rockdale Moraine, named for Rockdale, Will County, has a well defined front for 15 miles north of the Des Plaines River Valley and is represented by isolated, weakly morainic areas for 25 miles south of the valley.

**Wilton Center Drift** (Willman and Frye, 1970, p. 110)—The Wilton Center Moraine, named for Wilton Center, Will County, is traced for about 35 miles, from the vicinity of the Des Plaines Valley to the Indiana state line.

**Manhattan Drift** (Fisher and Ekblaw, in Fisher, 1925, p. 89)—The Manhattan Moraine, named for Manhattan, Will County, extends southward from Joliet for about 20 miles.

**Valparaiso Drifts**—The part of the Valparaiso Morainic System that is in the Joliet Sublobe is a complex of morainic ridges representing temporary stands of the ice front during the building of the system. Many ridges are indistinctly traced through parts of the complex but are undifferentiated in other parts. The Valparaiso Drift includes a buried drift of questionable age, informally called the Lemont drift (Bretz, 1955), which consists of yellow-gray silty till, sand and gravel, and dune sand, highly contorted in places. The Lemont drift occurs locally in the Worth, Sag Bridge, and Lemont areas in Cook County. It may be Woodfordian in age, but a leached zone on the gravel has been interpreted as possibly being the Sangamon Soil (Horberg and Potter, 1955) or the Farmdale Soil (Frye and Willman, 1970). It was tentatively assigned to the Winnebago Formation (Willman, 1971).

**West Chicago Drift** (Leighton, 1925, p. 69)—The West Chicago Moraine, named for West Chicago, Du Page County, forms the frontal ridge of the Valparaiso Morainic System from the Wisconsin border to the Indiana state line, about 100 miles. It is a rough-surfaced, gravelly moraine in the north but is more clayey south of West Chicago.

**Cary Drift** (Leighton, 1925, p. 69)—The Cary Moraine, named for Cary, McHenry County, occurs in both the Harvard Sublobe and the northern part of the Joliet Sublobe. It is about 30 miles long and consists of gravelly till assigned to the Haeger Till Member.

**Fox Lake Drift** (Powers and Ekblaw, 1940, p. 1331)—The Fox Lake Moraine, named for the town of Fox Lake, Lake County, is a kame-moraine traced for about 25 miles south from the Wisconsin state line. Most of it is gravel, and it is assigned to the Haeger Till Member, although the till in places is clayey and more like that in the Wadsworth Till Member.

**Wheaton Drift** (Ekblaw, in Suter et al., 1959, fig. 5)—The Wheaton Moraine, named for Wheaton, Du Page County, is traced for about 60 miles. It may be equivalent to the Cary Moraine, but cannot be traced in the intervening area.

**Keeneyville Drift** (Ekblaw, in Suter et al., 1959, fig. 5)—The Keeneyville Moraine, named for Keeneyville, Du Page County, is traced for about 40 miles. Its position in the Valparaiso Morainic System is similar to that of the Fox Lake Moraine farther north.

**Roselle Drift** (Ekblaw, in Suter et al., 1959, fig. 5)—The Roselle Moraine, named for Roselle, Du Page County, is a narrow ridge traced for about 10 miles.

**Palatine Drift** (Powers and Ekblaw, 1940, p. 1331)—The Palatine Moraine, named for Palatine, Cook County, is a relatively weak moraine traced for about 18 miles.

**Westmont Drift** (Willman and Frye, 1970, p. 112)—The Westmont Moraine, named for Westmont, Du Page County, is a poorly defined moraine traced for about 40 miles.

**Clarendon Drift** (Leighton, in Leighton and Willman, 1953, pl. 3)—The Clarendon Moraine, named for Clarendon Hills, Du Page County, is a poorly defined moraine traced for about 25 miles. It is the innermost moraine of the Valparaiso Morainic System.

**Tinley Drift** (Leighton and Ekblaw, 1932, p. 15; Bretz, 1939, p. 50)—The Tinley Moraine, named for Tinley Park, Cook County, the first moraine back of the Valparaiso Morainic System, extends from Wisconsin to Indiana, about 80 miles. It has a well defined front, except in the 25 miles south of the Wisconsin state line where it overlaps the Valparaiso Morainic System.

**Lake Border Drifts** (Leverett, 1897, p. 42)—The Lake Border Morainic System, named for its position near the shore of Lake Michigan, consists of five closely spaced moraines that are parallel except near the Wisconsin state line where they somewhat overlap. The moraines all consist of the gray clayey till of the Wadsworth Till Member.

**Park Ridge Drift** (Bretz, 1939, p. 55)—The Park Ridge Moraine, named for the city of Park Ridge, Cook County, is the outermost ridge of the Lake Border Morainic System and is traced from the Wisconsin state line southward for about 40 miles, where it ends at the Lake Chicago Plain. It recurs 12 miles farther south in an isolated segment at Blue Island.

**Deerfield Drift** (Bretz, 1939, p. 55)—The Deerfield Moraine, named for Deerfield, Lake County, is traced about 30 miles.

**Blodgett Drift** (Bretz, 1939, p. 56)—The Blodgett Moraine, named for Blodgett, Lake County, is traced for about 20 miles.

**Highland Park Drift** (Bretz, 1939, p. 56)—The Highland Park Moraine, named for Highland Park, Lake County, is traced for about 30 miles. The moraine terminates at the Lake Chicago Plain and the Lake Michigan beach.

**Zion City Drift** (Ekblaw, in Suter et al., 1959, fig. 5)—The Zion City Moraine, named for Zion (formerly called Zion City), Lake County, consists of patches of weak morainic topography near the Wisconsin state line. It is eroded at the Lake Michigan beach and is the youngest moraine in Illinois.

## REFERENCES

Names of certain organizations, journals, and series that are frequently cited are abbreviated more than is conventional, as follows:

AAAS—American Association for the Advancement of Science	GS —Geological Survey
AAPG—American Association of Petroleum Geologists	GSA —Geological Society of America
AJS —American Journal of Science	J —Journal
B —Bulletin	JG —Journal of Geology
C —Circular	RI —Report of Investigations
EGN —Environmental Geology Notes	USGS —United States Geological Survey

Other abbreviations are explained in *The Bibliography and Index of Illinois Geology Through 1965*, Illinois Geological Survey Bulletin 92.

## A

- ADAMS, G. I., 1904, Zinc and lead deposits of northern Arkansas: USGS Prof. Paper 24, 118 p.
- AGNEW, A. F., 1955, Facies of Middle and Upper Ordovician rocks of Iowa: AAPG B, v. 39, p. 1703-1752.
- AGNEW, A. F., and A. V. HEYL, JR., 1946, Quimbys Mill, new member of Platteville Formation, Upper Mississippi Valley: AAPG B, v. 30, p. 1585-1587.
- AGNEW, A. F., A. V. HEYL, JR., C. H. BEHRE, JR., and E. J. LYONS, 1956, Stratigraphy of Middle Ordovician rocks in the zinc-lead district of Wisconsin, Illinois, and Iowa: USGS Prof. Paper 274-K, p. 251-312.
- ALDEN, W. C., and M. M. LEIGHTON, 1917, Iowan drift, a review of the evidences of the Iowan Stage of glaciation: Iowa GS Ann. Rept., 1915, v. 26, p. 49-212.
- AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE, 1961, Code of stratigraphic nomenclature: AAPG B, v. 45, p. 645-665.
- ANDERSON, C. B., 1919, Artesian waters of northeastern Illinois: Ill. GS B 34, 326 p.
- ANDRESEN, M. J., 1956, Subsurface stratigraphy and sedimentation of the West Franklin-Cutler limestone zones of southern Illinois: Univ. Illinois M.S. thesis.
- ANDRESEN, M. J., 1961, Geology and petrology of the Trivoli Sandstone in the Illinois Basin: Ill. GS C 316, 31 p.
- ANDREWS, G. W., 1958, Windrow Formation of Upper Mississippi Valley region: JG, v. 66, p. 597-624.
- ARDUINO, GIOVANNI, 1760, Nuova raccolta di opuscoli scientifici e filologici del padre abate Angiolo Galogierà: Venice, Italy, tom. 6, p. 142-143.
- ASHLEY, G. H., 1899, Coal deposits of Indiana: Ind. Dept. Geol. and Nat. Res., 23rd Ann. Rept., 1898, p. 1-1573.
- ASHLEY, G. H., et al., 1933, Classification and nomenclature of rock units: GSA B, v. 44, p. 423-459.
- ATHERTON, ELWOOD, 1947, Some Chester outcrop and subsurface sections in southeastern Illinois: Ill. Acad. Sci. Trans., v. 40, p. 122-131; 1948, Ill. GS C 144.
- ATHERTON, ELWOOD, 1971, Tectonic development of the Eastern Interior Region of the United States: Ill. GS Ill. Petroleum 96, p. 29-43.
- ATHY, L. F., 1928, Geology and mineral resources of the Herscher Quadrangle: Ill. GS B 55, 120 p.

## B

- BAIN, H. F., 1897, Relations of the Wisconsin and Kansan drift sheets in central Iowa, and related phenomena: Iowa GS, v. 6, p. 429-476.
- BAIN, H. F., 1905, Zinc and lead deposits of northwestern Illinois: USGS B 246, 56 p.
- BAIN, H. F., 1906, Zinc and lead deposits of the Upper Mississippi Valley: USGS B 294, 155 p.
- BALL, J. R., 1938, Physiography and surficial geology of the Carlinville Quadrangle, Illinois: Ill. Acad. Sci. Trans. (1937), v. 30, p. 219-223; Ill. GS C 32.
- BALL, J. R., 1943, Pennsylvanian stratigraphy of the Carlinville, Illinois, Quadrangle: Ill. Acad. Sci. Trans., v. 36, p. 147-150; 1944, Ill. GS C 102.
- BALL, J. R., 1952, Geology and mineral resources of the Carlinville Quadrangle: Ill. GS B 77, 110 p.
- BALL, S. H., and A. F. SMITH, 1903, Geology of Miller County: Mo. Bur. Geol. and Mines (2), v. 1, 207 p.
- BANNISTER, H. M., 1868, Geology of Cook County: GS Ill., v. 3, p. 239-256.
- BASSETT, C. F., 1925, Devonian strata of the Alto Pass Quadrangle: Ill. Acad. Sci. Trans., v. 18, p. 360-368.
- BAXTER, J. W., 1960a, Salem Limestone in southwestern Illinois: Ill. GS C 284, 32 p.
- BAXTER, J. W., 1960b, *Calcisphaera* from the Salem (Mississippian) Limestone in southwestern Illinois: J. Paleont., v. 34, p. 1153-1157; Ill. GS Reprint 1961-B.
- BAXTER, J. W., and G. A. DESBOROUGH, 1965, Areal geology of the Illinois fluorspar district, Pt. 2—Karbers Ridge and Rosiclare Quadrangles: Ill. GS C 385, 40 p.
- BAXTER, J. W., G. A. DESBOROUGH, and C. W. SHAW, 1967, Areal geology of the Illinois fluorspar district, Pt. 3—Herod and Shettlerville Quadrangles: Ill. GS C 413, 41 p.
- BAXTER, J. W., P. E. POTTER, and F. L. DOYLE, 1963, Areal geology of the Illinois fluorspar district, Pt. 1—Saline Mines, Cave in Rock, Dekoven, and Repton Quadrangles: Ill. GS C 342, 43 p.
- BAYS, C. A., 1938, Stratigraphy of the Platteville Formation (abs.): GSA Proc. 1937, p. 269.
- BELL, A. H., ELWOOD ATHERTON, T. C. BUSCHBACH, and D. H. SWANN, 1964, Deep oil possibilities of the Illinois Basin: Ill. GS C 368, 38 p.

- BELL, A. H., C. G. BALL, and L. C. McCABE, 1931, Geology of the Pinckneyville and Jamestown areas, Perry County, Illinois: Ill. GS Ill. Petroleum 19, 22 p.
- BELL, W. C., R. R. BERG, and C. A. NELSON, 1956, Croixan type area—upper Mississippi Valley, in *El Sistema Cámbrico, su paleogeografía y el problema de su base*—symposium, Pt. 2: 20th Internat. Geol. Cong., p. 415-446.
- BERGSTROM, R. E., and T. R. WALKER, 1956, Ground-water geology of the East St. Louis area, Illinois: Ill. GS RI 191, 44 p.
- BERKEY, C. P., 1897, Geology of the St. Croix Dalles: Am. Geologist, v. 20, p. 345-383.
- BERRY, W. B. N., and A. J. BOUCOT, 1970, Correlation of the North American Silurian rocks: GSA Special Paper 102, 289 p.
- BERRY, W. B. N., and I. R. SATTERFIELD, 1972, Late Silurian graptolites from the Bainbridge Formation in southeastern Missouri: J. Paleon., v. 46, p. 492-498.
- BEVAN, A. C., 1926, Glenwood beds as a horizon marker at the base of the Platteville Formation: Ill. GS RI 9, 13 p.
- BEVAN, A. C., 1935, Cambrian inlier at Oregon, Illinois: Kans. Geol. Soc. Guidebook, 9th Ann. Field Conf., p. 383-385.
- BEVAN, A. C., 1939, Cambrian inlier in northern Illinois: AAPG B, v. 23, p. 1561-1564.
- BLACK, R. F., and MEYER RUBIN, 1968, Radiocarbon dates of Wisconsin: Wis. Acad. Sci., Arts, and Letters, v. 56, p. 99-115.
- BLATCHLEY, R. S., 1914, Plymouth oil field: Ill. GS Extract B 23, p. 5-7.
- BOND, D. C., et al., 1971, Possible future petroleum potential of Region 9—Illinois Basin, Cincinnati Arch, and northern Mississippi Embayment: AAPG Mem. 15, v. 2, p. 1165-1218; Ill. GS Reprint 1971-M.
- BORDEN, W. W., 1874, Report of a geological survey of Clark and Floyd Counties, Indiana: Ind. GS Ann. Rept. 5, p. 134-189.
- BRADBURY, J. C., 1965, Limestone resources of Jefferson and Marion Counties, Illinois: Ill. GS Industrial Minerals Note 23, 15 p.
- BRADBURY, J. C., and ELWOOD ATHERTON, 1965, Precambrian basement of Illinois: Ill. GS C 382, 13 p.
- BRADLEY, F. H., 1870, Geology of Vermilion County: GS Ill., v. 4, p. 241-265.
- BRETZ, J. H., 1939, Geology of the Chicago region, Pt. 1—General: Ill. GS B 65, 118 p.
- BRETZ, J. H., 1955, Geology of the Chicago region, Pt. 2—Pleistocene: Ill. GS B 65, 132 p.
- BRISTOL, H. M., 1968, Structure of the base of the Mississippian Beech Creek (Barlow) Limestone in Illinois: Ill. GS Ill. Petroleum 88, 12 p.
- BRISTOL, H. M., and T. C. BUSCHBACH, 1973, Ordovician Galena Group (Trenton)—Structure and oil fields: Ill. GS Ill. Petroleum 99, 38 p.
- BRISTOL, H. M., and R. H. HOWARD, 1971, Paleogeologic map of the sub-Pennsylvanian Chesterian (upper Mississippian) surface in the Illinois Basin: Ill. GS C 458, 14 p.
- BRISTOL, H. M., and R. H. HOWARD, 1974, Sub-Pennsylvanian valleys in the Chesterian surface of the Illinois Basin and related Chesterian slump blocks, in *Carboniferous of the southeastern United States: Symposium*, GSA Special Paper 148, p. 315-336; Ill. GS Reprint 1974-T.
- BROADHEAD, G. C., 1875, Geology of Shelby County: GS Ill., v. 6, p. 163-174.
- BROKAW, A. D., 1916, Preliminary oil report on southern Illinois: Ill. GS Extract B 35, 13 p.
- BROWN, C. E., and J. W. WHITLOW, 1960, Geology of the Dubuque South Quadrangle, Iowa-Illinois: USGS B 1123-A, p. 1-93.
- BUCKLEY, E. R., 1907, Mo. Bur. Geol. and Mines, 2nd Ser., v. 10, *separate*.
- BUCKLEY, E. R., 1908, Lead and zinc resources of Missouri: Am. Mining Cong. Rept. Proc. 10th Ann. Sess., p. 282-297.
- BUCKLEY, E. R., 1909, Geology of the disseminated lead deposits of St. Francois and Washington Counties: Mo. Bur. Geol. and Mines, 2nd Ser., v. 9, pt. 1, 259 p.
- BUCKLEY, E. R., and H. A. BUEHLER, 1904, Quarrying industry in Missouri: Mo. Bur. Geol. and Mines, v. 2, 371 p.
- BUSCHBACH, T. C., 1952, Chouteau Formation of Illinois: Ill. Acad. Sci. Trans., v. 45, p. 108-115; 1953, Ill. GS C 183.
- BUSCHBACH, T. C., 1961, Morphology of the sub-St. Peter surface of northeastern Illinois: Ill. Acad. Sci. Trans., v. 54, p. 83-89; Ill. GS Reprint 1961-Y.
- BUSCHBACH, T. C., 1964, Cambrian and Ordovician strata of northeastern Illinois: Ill. GS RI 218, 90 p.
- BUSCHBACH, T. C., 1971, Stratigraphic setting of the Eastern Interior Region of the United States: Ill. GS Ill. Petroleum 96, p. 3-20.
- BUSCHBACH, T. C., and G. E. HEIM, 1972, Preliminary geologic investigations of rock tunnel sites for flood and pollution control in the Greater Chicago Area: Ill. GS EGN 52, 35 p.
- BUSCHBACH, T. C., and ROBERT RYAN, 1963, Ordovician explosion structure at Glasford, Illinois: AAPG, v. 47, p. 2015-2022; Ill. GS Reprint 1964-B.
- BUTTS, CHARLES, 1917, Descriptions and correlations of the Mississippian formations of western Kentucky, Pt. 1 of Mississippian formations of western Kentucky: Ky. GS, v. 1, 119 p.
- BUTTS, CHARLES, 1925, Geology and mineral resources of the Equality-Shawneetown area: Ill. GS B 47, 76 p.

## C

- CADY, G. H., 1908, Cement making materials in the vicinity of La Salle, in *Year-Book for 1907*: Ill. GS B 8, p. 127-134.
- CADY, G. H., 1915, Coal resources of District I (Longwall): Ill. GS Mining Inv. B 10, 149 p.
- CADY, G. H., 1919a, Coal resources of District V (Saline and Gallatin Counties): Ill. GS Mining Inv. B 19, 135 p.
- CADY, G. H., 1919b, Geology and mineral resources of the Hennepin and La Salle Quadrangles: Ill. GS B 37, 136 p.
- CADY, G. H., 1926, Areal geology of Saline County: Ill. Acad. Sci. Trans., v. 19, p. 250-272.
- CADY, G. H., 1935, Classification and selection of Illinois coals: Ill. GS B 62, 354 p.
- CADY, G. H., 1942, Analysis of Illinois coals: U.S. Bur. Mines Tech. Paper 641, p. 1-23.
- CADY, G. H., 1948, Analyses of Illinois coals: Ill. GS Supplement B 62, 77 p.
- CADY, G. H., et al., 1952, Movable coal reserves of Illinois: Ill. GS B 78, 138 p.
- CALVIN, SAMUEL, 1897, Synopsis of the drift deposits of Iowa: Am. Geologist, v. 19, p. 270-272.
- CALVIN, SAMUEL, 1906, Geology of Winneshiek County: Iowa GS, v. 16, p. 37-146.
- CAMPBELL, GUY, 1946, New Albany Shale: GSA B, v. 57, p. 829-908.
- CARMAN, J. E., 1910, Mississippi Valley between Savanna and Davenport: Ill. GS B 13, 96 p.
- CATACOSINOS, P. A., 1973, Cambrian lithostratigraphy of Michigan Basin: AAPG B, v. 57, p. 2404-2418.

- CHAMBERLIN, T. C., 1894, Glacial phenomena of North America, in James Geikie, The great ice age [3rd ed.]: D. Appleton & Co., New York, p. 724-774.
- CHAMBERLIN, T. C., 1895, Classification of American glacial deposits: JG, v. 3, p. 270-277.
- CHAMBERLIN, T. C., 1896, Editorial: JG, v. 4, p. 872-876.
- CLARKE, J. M., and CHARLES SCHUCHERT, 1899, Nomenclature of the New York series of geological formations: Science, v. 10, p. 874-878.
- CLEGG, K. E., and J. C. BRADBURY, 1956, Igneous intrusive rocks in Illinois and their economic significance: Ill. GS RI 197, 19 p.
- CLINE, L. M., 1941, Traverse of upper Des Moines and lower Missouri series from Jackson County, Missouri, to Appanoose County, Iowa: AAPG B, v. 25, p. 23-72.
- COHEE, G. V., 1968, Holocene replaces Recent in nomenclature usage of the U.S. Geological Survey: AAPG B, v. 52, p. 852.
- COLLETT, JOHN, 1871, Geology of Sullivan County, Indiana: Ind. GS, 2nd Ann. Rept., p. 190-240.
- COLLETT, JOHN, 1882, Eleventh annual report: Ind. Dept. Geol. and Nat. Hist., 414 p.
- COLLETT, JOHN, 1884, Geology of Posey County, Indiana: Ind. Dept. Geol. and Nat. Hist., 13th Ann. Rept., p. 45-70.
- COLLINSON, CHARLES, 1957, Ordovician, Silurian, Devonian, and Mississippian rocks of western Illinois: Ill. Geol. Soc. Guidebook, 24 p.
- COLLINSON, CHARLES, 1961, Kinderhookian Series in the Mississippi Valley, in Northeastern Missouri and west-central Illinois: Kans. Geol. Soc. Guidebook, 26th Ann. Field Conf., Mo. GS RI 27, p. 100-109; Ill. GS Reprint 1961-U.
- COLLINSON, CHARLES, 1964, Western Illinois: 28th Ann. Tri-State Field Conf., Quincy, Ill., Ill. GS Guidebook Ser. 6, 30 p.
- COLLINSON, CHARLES, 1967, Devonian of the north-central region, United States, in International symposium on the Devonian System: Alberta Soc. Petroleum Geologists, v. 1, p. 933-939; Ill. GS Reprint 1968-G.
- COLLINSON, CHARLES, 1969, Devonian-Mississippian biostratigraphy of northeastern Missouri and western Illinois: North Am. Paleontological Convention Field Trip 3, 23 p.
- COLLINSON, CHARLES, and H. R. SCHWALB, 1955, North American Paleozoic Chitinozoa: Ill. GS RI 186, 33 p.
- COLLINSON, CHARLES, and A. J. SCOTT, 1958a, Age of the Springfield Shale (Mississippian) of southern Illinois: Ill. GS C 254, 12 p.
- COLLINSON, CHARLES, and A. J. SCOTT, 1958b, Chitinozoan faunule of the Devonian Cedar Valley Formation: Ill. GS C 247, 34 p.
- COLLINSON, CHARLES, L. E. BECKER, G. W. JAMES, J. W. KOENIG, and D. H. SWANN, 1967a, Illinois Basin, in International symposium on the Devonian System: Alberta Soc. Petroleum Geologists, v. 1, p. 940-962; Ill. GS Reprint 1968-G.
- COLLINSON, CHARLES, M. P. CARLSON, F. H. DORHEIM, and J. W. KOENIG, 1967b, Central Iowa Basin, in International symposium on the Devonian System: Alberta Soc. Petroleum Geologists, v. 1, p. 963-971; Ill. GS Reprint 1968-G.
- COLLINSON, CHARLES, C. B. REXROAD, and T. L. THOMPSON, 1971, Conodont zonation of the North American Mississippian: GSA Mem. 127, p. 353-395; Ill. GS Reprint 1972-A.
- COLLINSON, CHARLES, A. J. SCOTT, and C. B. REXROAD, 1962, Six charts showing biostratigraphic zones and correlations based on conodonts from the Devonian and Mississippian rocks of the Upper Mississippi Valley: Ill. GS C 328, 32 p.
- COLLINSON, CHARLES, D. H. SWANN, and H. B. WILLMAN, 1954, Guide to the structure and Paleozoic stratigraphy along the Lincoln Fold in western Illinois: Ill. GS Guidebook Ser. 3, 75 p.
- COOPER, C. L., 1946, Pennsylvanian ostracodes of Illinois: Ill. GS B 70, 177 p.
- COOPER, C. L., 1947, Upper Kinkaid (Mississippian) microfauna from Johnson County, Illinois: J Paleon., v. 21, p. 81-94; Ill. GS RI 122.
- COOPER, G. A., 1944, Remarks on correlation of Devonian formations in Illinois and adjacent states: Ill. GS B 68, p. 217-222.
- COOPER, G. A., 1945, New species of brachiopods from the Devonian of Illinois and Missouri: J Paleon., v. 19, p. 479-489.
- COOPER, G. A., and P. E. CLOUD, JR., 1938, New Devonian fossils from Calhoun County, Illinois: J Paleon., v. 12, p. 444-460.
- COOPER, G. A., et al., 1942, Correlation of the Devonian sedimentary formations of North America: GSA B, v. 53, p. 1729-1794.
- COX, E. T., 1875, Geology of Gallatin County: GS Ill., v. 6, p. 197-219.
- COX, G. H., 1914, Lead and zinc deposits of northwestern Illinois: Ill. GS B 21, 120 p.
- CRIDER, A. F., and L. C. JOHNSON, 1906, Summary of the underground water resources of Mississippi: USGS Water Supply Paper 159, 86 p.
- CRONEIS, C. G., 1944, Devonian of southeastern Missouri: Ill. GS B 68, p. 103-131.
- CULVER, H. E., 1922a, Geology and mineral resources of the Morris Quadrangle: Ill. GS Extract B 43B, 114 p.
- CULVER, H. E., 1922b, Note on the occurrence of fusulinas in the Pennsylvanian rocks of Illinois: Ill. Acad. Sci. Trans., v. 15, p. 421-425.
- CULVER, H. E., 1925, Coal resources of District III (western Illinois): Ill. GS Mining Inv. B 29, 128 p.
- CUMINGS, E. R., 1901, Use of Bedford as a formational name: JG, v. 9, p. 232-233.
- CUMINGS, E. R., 1922, Nomenclature and description of the geological formations of Indiana, in Handbook of Indiana geology: Ind. Dept. Conserv. Pub. 21, p. 403-570.

## D

- DAMBERGER, H. H., 1971, Coalification pattern of the Illinois Basin: Econ. Geol., v. 66, p. 488-494; Ill. GS Reprint 1971-D.
- DANA, J. D., 1874, Reasons for some of the changes in the subdivisions of geological time in the new edition of Dana's Manual of Geology: AJS, v. 8, p. 213-216.
- DANA, P. L., and E. H. SCOBAY, 1941, Cross section of Chester of Illinois Basin: AAPG B, v. 25, p. 871-882.
- DAPPLES, E. C., 1955, General lithofacies relationship of St. Peter Sandstone and Simpson Group: AAPG B, v. 39, p. 444-467.
- DESNOYERS, J., 1829, Observations sur un ensemble de dépôts marins plus récents que les terrains tertiaires du bassin de la Seine, et constituant une formation géologique distincte; précédées d'un aperçu de la non simultanéité des bassins tertiaires: Annales Sci. Nat., v. 16, p. 171-214, 402-491.
- DEWOLF, F. W., 1910, Studies of Illinois coal—Introduction: in Year-book for 1909, Ill. GS B 16, p. 178-181.
- DEWOLF, F. W., et al., 1917, Geologic map of Illinois: Ill. GS.
- D'HALLOY, J. J. D'OMALIUS, 1822, Observations sur un essai de carte géologique de la France, des Pays-Bas et des contrées voisines: Annales des Mines, v. 7, p. 373-374.

- DUBOIS, E. P., 1945, I. Subsurface relations of the Maquoketa and "Trenton" Formations in Illinois: Ill. GS RI 105, p. 7-33.
- DUNBAR, C. O., and L. G. HENBEST, 1942, Pennsylvanian Fusulinidae of Illinois: Ill. GS B 67, 218 p.
- DUNN, P. H., 1942, Silurian Foraminifera of the Mississippi Basin: J. Paleon., v. 16, p. 317-342.

## E

- EBRIGHT, J. R., C. R. FETTKKE, and A. I. INGHAM, 1949, East Fork-Wharton gas field, Potter County, Pennsylvania: Penn. GS B M30, Ser. 4, 43 p.
- EDMUND, R. W., and R. C. ANDERSON, 1967, Mississippi River Arch: 31st Ann. Tri-State Field Conf. Guidebook, Augustana College, Rock Island, Ill., 64 p.
- EKBLAW, G. E., 1932, Landslides near Peoria: Ill. Acad. Sci. Trans. (1931), v. 24, p. 350-353.
- EKBLAW, G. E., 1941, Glacial map of northeastern Illinois: Ill. GS.
- EKBLAW, S. E., 1931, Channel deposits of the Pleasantview Sandstone in western Illinois: Ill. Acad. Sci. Trans., v. 23, p. 391-399.
- EMMONS, EBENEZER, 1838, Report of the Second Geological District of the State of New York: N.Y. GS, 2nd Ann. Rept., p. 186-252.
- EMMONS, EBENEZER, 1842, Geology of New York, Pt. 2, comprising the survey of the second geological district: Albany, 437 p.
- EMRICH, G. H., 1966, Ironton and Galesville (Cambrian) Sandstones in Illinois and adjacent areas: Ill. GS C 403, 55 p.
- EMRICH, G. H., and R. E. BERGSTROM, 1962, Des Plaines Disturbance, northeastern Illinois: GSA B, v. 73, p. 959-968; Ill. GS Reprint 1962-T.
- ENGELMANN, GEORGE, 1947, Remarks on the St. Louis Limestone: AJS, v. 3, p. 119-120.
- ENGELMANN, HENRY, 1863, On the Lower Carboniferous System as developed in southern Illinois: St. Louis Acad. Sci. Trans., v. 2, pt. 1, p. 188-190.
- ENGELMANN, HENRY, 1868, Geology of Clinton and Washington Counties: GS Ill., v. 3, p. 145-191.
- ENGLISH, R. M., and R. M. GROGAN, 1948, Omaha pool and mica-peridotite intrusives, Gallatin County, Illinois, in Structure of typical American oil fields, 3: AAPG, p. 189-212; Ill. GS RI 130.
- EVENSON, E. B., 1973, Late Pleistocene shorelines and stratigraphic relations in the Lake Michigan basin: GSA B, v. 84, p. 2281-2298.
- FRYE, J. C., and N. F. SHIMP, 1973, Major, minor, and trace elements in sediments of late Pleistocene Lake Saline compared with those in Lake Michigan sediments: Ill. GS EGN 60, 14 p.
- FRYE, J. C., and H. B. WILLMAN, 1960, Classification of the Wisconsin Stage in the Lake Michigan glacial lobe: Ill. GS C 285, 16 p.
- FRYE, J. C., and H. B. WILLMAN, 1962, Note 27—Morpho-stratigraphic units in Pleistocene stratigraphy: AAPG B, v. 46, p. 112-113; Ill. GS Reprint 1962-F.
- FRYE, J. C., 1965, Illinois, in Guidebook for field conferences C and G—Upper Mississippi Valley: Internat. Assoc. Quaternary Research 7th Cong., Neb. Acad. Sci., p. 5-26, 81-110; Ill. GS Reprint 1966-B.
- FRYE, J. C., and H. B. WILLMAN, 1970, Rock stratigraphy in the Illinois Pleistocene: 34th Ann. Tri-State Field Conf. Guidebook, Northern Ill. Univ., De Kalb, Ill., p. 60-64; Ill. GS Reprint 1970-Q.
- FRYE, J. C., L. R. FOLLMER, H. D. GLASS, J. M. MASTERS, and H. B. WILLMAN, 1974a, Earliest Wisconsinan sediments and soils: Ill. GS C 485, 12 p.
- FRYE, J. C., H. D. GLASS, J. P. KEMPTON, and H. B. WILLMAN, 1969, Glacial tills of northwestern Illinois: Ill. GS C 437, 47 p.
- FRYE, J. C., H. D. GLASS, and H. B. WILLMAN, 1962, Stratigraphy and mineralogy of the Wisconsinan loesses of Illinois: Ill. GS C 334, 55 p.
- FRYE, J. C., H. D. GLASS, and H. B. WILLMAN, 1968a, Mineral zonation of Woodfordian loesses of Illinois: Ill. GS C 427, 44 p.
- FRYE, J. C., A. B. LEONARD, H. B. WILLMAN, and H. D. GLASS, 1972, Geology and paleontology of late Pleistocene Lake Saline, southeastern Illinois: Ill. GS C 471, 44 p.
- FRYE, J. C., A. B. LEONARD, H. B. WILLMAN, H. D. GLASS, and L. R. FOLLMER, 1974b, Late Woodfordian Jules Soil and associated molluscan faunas: Ill. GS C 486, 11 p.
- FRYE, J. C., ADA SWINEFORD, and A. B. LEONARD, 1948, Correlation of Pleistocene deposits of the central Great Plains with the glacial section: JG, v. 56, p. 501-525.
- FRYE, J. C., H. B. WILLMAN, and R. F. BLACK, 1965, Outline of glacial geology of Illinois and Wisconsin, in Quaternary of the United States: Internat. Assoc. Quaternary Research 7th Cong., Princeton Univ. Press, p. 43-61; Ill. GS Reprint 1965-N.
- FRYE, J. C., H. B. WILLMAN, and H. D. GLASS, 1964, Cretaceous deposits and the Illinoian glacial boundary in western Illinois: Ill. GS C 364, 28 p.
- FRYE, J. C., H. B. WILLMAN, MEYER RUBIN, and R. F. BLACK, 1968b, Definition of Wisconsinan Stage: USGS B 1274-E, p. E1-E22.
- FULLER, M. L., and G. H. ASHLEY, 1902, Ditney Quadrangle: USGS Geol. Atlas Folio 84, 8 p.
- FULLER, M. L., and F. G. CLAPP, 1904, Patoka, Indiana-Illinois Quadrangle: USGS Geol. Atlas Folio 105, 12 p.

## F

- FISHER, D. J., 1925, Geology and mineral resources of the Joliet Quadrangle: Ill. GS B 51, 160 p.
- FISS, H. N., 1944, Geological investigation of the alluvial valley of the lower Mississippi River: Mississippi River Comm., War Dept., Corps of Engineers, U.S. Army, 78 p.
- FOERSTE, A. F., 1905, Classification of the Ordovician rocks of Ohio and Indiana: Science, v. 22, p. 149-152.
- FORBES, EDWARD, 1846, On the connection between the distribution of the existing fauna and flora of the British Isles, and the geological changes which have affected their area, especially during the epoch of the northern drift: Great Britain GS Mem., v. 1, p. 336-432.
- FRYE, J. C., and A. B. LEONARD, 1951, Stratigraphy of the late Pleistocene loesses of Kansas: JG, v. 59, p. 287-305.
- FRYE, J. C., and A. B. LEONARD, 1952, Pleistocene geology of Kansas: Kans. GS B 99, 230 p.

## G

- GLASS, H. D., J. C. FRYE, and H. B. WILLMAN, 1968, Clay mineral composition, a source indicator of Midwest loess, in Quaternary of Illinois: Univ. Ill. Coll. Agr. Special Pub. 14, p. 35-40.
- GLENN, L. C., 1906, Underground waters of Tennessee and Kentucky west of Tennessee River and of an adjacent area in Illinois: USGS Water Supply and Irrig. Paper 164, 173 p.
- GLENN, L. C., 1912, A geological reconnaissance of the Tradewater River region, with special reference to the coal beds: Ky. GS B 17, 75 p.
- GLUSKOTER, H. J., and M. E. HOPKINS, 1970, Distribution of sulfur in Illinois coals: Ill. GS Guidebook Ser. 8, p. 89-95.

- GLUSKOTER, H. J., and J. A. SIMON, 1968, Sulfur in Illinois coals: Ill. GS C 432, 28 p.
- GRABAU, A. W., 1909, Physical and faunal evolution of North America during Ordovician, Silurian, and early Devonian time: JG, v. 17, p. 209-252.
- GRAY, H. H., 1972, Lithostratigraphy of the Maquoketa Group (Ordovician) in Indiana: Ind. GS Special Rept. 7, 31 p.
- GRAY, H. H., R. D. JENKINS, and R. M. WEIDMAN, 1960, Geology of the Huron area, south-central Indiana: Ind. GS B 20, 78 p.
- GRIMMER, J. C., 1968, Stratigraphy of the Middle Devonian shales of southern Illinois: Ill. Acad. Sci. Trans., v. 61, p. 407-415.
- GROGAN, R. M., 1949, Present state of knowledge regarding the Pre-Cambrian crystallines of Illinois: Ill. Acad. Sci. Trans., v. 42, p. 97-102; 1950, Ill. GS C 157.
- GROSS, D. L., J. A. LINEBACK, W. A. WHITE, N. J. AYER, CHARLES COLLINSON, and H. V. LELAND, 1970, Studies of Lake Michigan bottom sediments—No. 1. Preliminary stratigraphy of unconsolidated sediments from the southwestern part of Lake Michigan: Ill. GS EGN 30, 20 p.
- GUTSTADT, A. M., 1958a, Cambrian and Ordovician stratigraphy and oil and gas possibilities in Indiana: Ind. GS B 14, 103 p.
- GUTSTADT, A. M., 1958b, Upper Ordovician stratigraphy in Eastern Interior region: AAPG B, v. 42, p. 513-547.
- ## H
- HALL, JAMES, 1842, Geology of the Western States: AJS, v. 42, p. 51-62.
- HALL, JAMES, 1843, Geology of New York—Pt. 4, with geological map of middle and western states: Albany, N.Y., 685 p.
- HALL, JAMES, 1851, Lower Silurian System; Upper Silurian and Devonian Series, in Report on the geology of the Lake Superior land district, Pt. 2: U.S. 32nd Cong. Special Sess., Senate Exec. Doc. 4, p. 140-166; AJS, v. 17, p. 181-194.
- HALL, JAMES, 1857, Observations upon the Carboniferous limestones of the Mississippi Valley (abs.): AJS, v. 23, p. 187-203.
- HALL, JAMES, 1861, Descriptions of new species of Crinoida; investigations of the Iowa Geological Survey, preliminary notice: Albany, N.Y., 19 p.
- HARLAND, W. B. (ed.), 1964, The Phanerozoic time scale: Quarterly J. Geol. Soc. London, 458 p.
- HAYES, W. C., and R. D. KNIGHT, 1961, Cambrian System, in Stratigraphic succession in Missouri: Mo. GS, v. 40, p. 14-20.
- HEIGOLD, P. C., in preparation, An aeromagnetic survey of southwestern Illinois: Ill. GS C.
- HENBEST, L. G., 1928, Fusulinellas from the Stonefort Limestone Member of the Tradewater Formation: J. Paleon., v. 2, p. 70-85.
- HERBERT, PAUL, JR., 1949, Stratigraphy of the Decorah Formation in western Illinois: Univ. Chicago Ph.D. thesis; Ill. GS manuscript PH-1.
- HERSHEY, O. H., 1894, Elk Horn Creek area of St. Peter Sandstone in northwestern Illinois: Am. Geologist, v. 14, p. 169-179.
- HERSHEY, O. H., 1897, The term Pecatonica Limestone: Am. Geologist, v. 20, p. 66-67.
- HESTER, N. C., and G. S. FRASER, 1973, Sedimentology of a beach ridge complex and its significance in land-use planning: Ill. GS EGN 63, 24 p.
- HESTER, N. C., and J. E. LAMAR, 1969, Peat and humus in Illinois: Ill. GS Industrial Minerals Note 37, 14 p.
- HILGARD, E. W., 1860, Report on the geology and agriculture of the State of Mississippi: Jackson, Miss., p. 79, 84-91, 102.
- HILL, R. T., 1887, Topography and geology of the Cross Timbers and surrounding regions in northern Texas: AJS, v. 33, p. 291-303.
- HINDS, HENRY, 1914, Oil and gas in the Colchester-Macomb Quadrangles: Ill. GS Extract B 23, p. 8-13.
- HOPKINS, M. E., 1958, Geology and petrology of the Anvil Rock Sandstone of southern Illinois: Ill. GS C 256, 49 p.
- HOPKINS, M. E., 1968, Harrisburg (No. 5) Coal reserves of southeastern Illinois: Ill. GS C 431, 25 p.
- HOPKINS, T. C., and C. E. SIEBENTHAL, 1897, Bedford oolitic limestone of Indiana: Ind. Dept. Geol. and Nat. Res., Ann. Rept. 21, p. 291-427.
- HORBERG, C. L., 1950a, Bedrock topography of Illinois: Ill. GS B 73, 111 p.
- HORBERG, C. L., 1950b, Preglacial gravels in Henry County, Illinois: Ill. Acad. Sci. Trans., v. 43, p. 171-175; Ill. GS C 170.
- HORBERG, C. L., 1953, Pleistocene deposits below the Wisconsin drift in northeastern Illinois: Ill. GS RI 165, 61 p.
- HORBERG, C. L., and P. E. POTTER, 1955, Stratigraphic and sedimentologic aspects of the Lemont drift of northeastern Illinois: Ill. GS RI 185, 23 p.
- HOWARD, R. H., 1961, Oil and gas in the Adams-Brown-Schuyler County area, Illinois: Ill. GS C 325, 23 p.
- HOWE, W. B., and J. W. KOENIG, 1961, Stratigraphic succession in Missouri: Mo. GS, v. 40, 185 p.
- HOWELL, B. F., et al., 1944, Correlation of the Cambrian formations of North America: GSA B, v. 55, p. 993-1003.
- HUGHES, O. L., 1956, Surficial geology of Smooth Rock, Cochrane district, Ontario: Canada GS Paper 55-41, 9 p.
- ## I
- INDEN, RICHARD, 1968, Petrographic analysis and environmental interpretation of the Breezy Hill Limestone in Illinois, Missouri, Kansas, and Oklahoma: Univ. Illinois thesis.
- INGELS, J. J. C., 1963, Geometry, paleontology, and petrography of Thornton Reef Complex, Silurian of northeastern Illinois: AAPG B, v. 47, p. 405-440.
- ## J
- JACOBS, A. M., and J. A. LINEBACK, 1969, Glacial geology of the Vandalia, Illinois, region: Ill. GS C 442, 23 p.
- JAMES, ALAN, 1968, Middle Devonian strata of northwestern Illinois and southeastern Iowa: Univ. Illinois M.A. thesis.
- JAMES, H. L., 1972, Stratigraphic Commission Note 40—Subdivision of Precambrian: AAPG B, v. 56, p. 1128-1133.
- JEWETT, J. M., 1941, Classification of the Marmaton Group, Pennsylvanian, in Kansas: Kans. GS B 58, p. 1-148.
- JOHNSON, R. G., and E. S. RICHARDSON, JR., 1970, Fauna of the Francis Creek Shale in the Wilmington area: Ill. GS Guidebook Ser. 8, p. 53-60.
- JOHNSON, W. H., 1964, Stratigraphy and petrography of Illinoian and Kansan drift in central Illinois: Ill. GS C 378, 38 p.
- JOHNSON, W. H., 1971, Old glacial drift near Danville, Illinois: Ill. GS C 457, 16 p.
- JOHNSON, W. H., L. R. FOLLMER, D. L. GROSS, and A. M. JACOBS, 1972, Pleistocene stratigraphy of east-central Illinois: Ill. GS Guidebook Ser. 9, 97 p.
- JOHNSON, W. H., D. L. GROSS, and S. R. MORAN, 1971, Till stratigraphy of the Danville region, east-central Illinois; in Till—a symposium: Ohio State Univ. Press, p. 184-216; Ill. GS Reprint 1972-1.

## K

- KAY, F. H., 1915, Coal resources of District VII (Coal No. 6 west of Duquoin anticline): Ill. GS Mining Inv. 11, 233 p.
- KAY, G. F., and M. M. LEIGHTON, 1933, Eldoran Epoch of the Pleistocene Period: GSA B, v. 44, p. 669-674.
- KAY, MARSHALL, 1928, Divisions of the Decorah Formation: Science, v. 67, p. 16.
- KAY, MARSHALL, 1931, Stratigraphy of the Ordovician Hounsfield Metabentonite: JG, v. 39, p. 361-376.
- KAY, MARSHALL, 1935a, Ordovician Stewartville-Dubuque problems: JG, v. 43, p. 561-590.
- KAY, MARSHALL, 1935b, Ordovician System in the Upper Mississippi Valley: Kans. Geol. Soc. Guidebook, 9th Ann. Field Conf., p. 281-295.
- KAY, MARSHALL, 1948, Summary of Middle Ordovician bordering Allegheny Synclinorium: AAPG B, v. 32, p. 1397-1416.
- KAY, MARSHALL, 1954, Upper Mississippi Valley: Column 50, chart 2, in W. H. Twenhofel et al., 1954.
- KAY, MARSHALL, 1960, Classification of the Ordovician System in North America: 21st Internat. Geol. Cong., Copenhagen, 1960, Repts., pt. 7, p. 28-33.
- KEMPTON, J. P., 1963, Subsurface stratigraphy of the Pleistocene deposits of central northern Illinois: Ill. GS C 356, 43 p.
- KEMPTON, J. P., and J. E. HACKETT, 1968, Stratigraphy of the Woodfordian and Altonian drifts of central northern Illinois, in Quaternary of Illinois: Univ. Illinois Coll. Agr. Special Pub. 14, p. 27-34; Ill. GS Reprint 1968-Z.
- KENNEDY, E. J., R. R. RUCH, and N. F. SHIMP, 1971, Studies of Lake Michigan bottom sediments—No. 7. Distribution of mercury in unconsolidated sediments from southern Lake Michigan: Ill. GS EGN 44, 18 p.
- KEROHER, G. C., 1970, Lexicon of geologic names of the United States for 1961-1967: USGS B 1350, 848 p.
- KEYES, C. R., 1892, Principal Mississippian section: GSA B, v. 3, p. 283-300.
- KEYES, C. R., 1893, Geological formations of Iowa: Iowa GS, v. 1, p. 11-144.
- KEYES, C. R., 1894, Paleontology of Missouri (Part I): Mo. GS, v. 4, 271 p.
- KEYES, C. R., 1895, Geology of Lee County: Iowa GS, v. 3, p. 305-407.
- KEYES, C. R., 1898, Some geological formations of the Capau-Grès uplift: Iowa Acad. Sci. Proc., v. 5, p. 58-63.
- KEYES, C. R., 1912, Some provincial and local phases of the general geologic section of Iowa: Iowa Acad. Sci. Proc., v. 19, p. 147-151.
- KEYES, C. R., 1913, Late Devonian sequence of the Iowa region (synopsis): Iowa Acad. Sci. Proc., v. 20, p. 205-206.
- KLAPPER, GILBERT, and W. M. FURNISH, 1962, Conodont zonation of the early Upper Devonian in eastern Iowa: Iowa Acad. Sci. Proc., v. 69, p. 400-410.
- KOENIG, J. W., 1961, Devonian System, in Stratigraphic succession in Missouri: Mo. GS, v. 40, p. 36-49.
- KOSANKE, R. M., 1950, Pennsylvanian spores of Illinois and their use in correlation: Ill. GS B 74, 128 p.
- KOSANKE, R. M., J. A. SIMON, H. R. WANLESS, and H. B. WILLMAN, 1960, Classification of the Pennsylvanian strata of Illinois: Ill. GS RI 214, 84 p.

## L

- LADD, H. S., 1929, Stratigraphy and paleontology of the Maquoketa Shale of Iowa: Iowa GS, v. 34, p. 305-448.
- LAMAR, J. E., 1925, Geology and mineral resources of the Carbondale Quadrangle: Ill. GS B 48, 172 p.
- LAMAR, J. E., 1928a, Geology and economic resources of the St. Peter Sandstone of Illinois: Ill. GS B 53, 175 p.
- LAMAR, J. E., 1928b, Preliminary report on the fuller's earth deposits of Pulaski County: Ill. GS RI 15, 31 p.
- LAMAR, J. E., 1953, Siliceous materials of extreme southern Illinois: Ill. GS RI 166, 39 p.
- LAMAR, J. E., and R. R. REYNOLDS, 1951, Notes on the Illinois "Lafayette" Gravel: Ill. Acad. Sci. Trans., v. 44, p. 95-108; Ill. GS C 179.
- LAMAR, J. E., and A. H. SUTTON, 1930, Cretaceous and Tertiary sediments of Kentucky, Illinois, and Missouri: AAPG B, v. 14, p. 845-866.
- LAMAR, J. E., and H. B. WILLMAN, 1931, High-calcium limestone near Morris, Illinois: Ill. GS RI 23, 26 p.
- LAMAR, J. E., H. B. WILLMAN, C. F. FRYLING, and W. H. VOSKUIL, 1934, Rock wool from Illinois mineral resources: Ill. GS B 61, 262 p.
- LANDON, D. W., 1891, Variations in the Cretaceous and Tertiary strata of Alabama: GSA B, v. 2, p. 587-605.
- LAPWORTH, C., 1879, On the tripartite classification of the lower Paleozoic rocks: Geol. Mag., n.s., Decade II, v. 6, p. 1-15.
- LAUDON, L. R., 1931, Stratigraphy of the Kinderhook Series of Iowa: Iowa GS, v. 35, p. 333-451.
- LAUDON, L. R., 1935, Supplemental statement on the Mississippian System in Iowa: Kans. Geol. Soc. 9th Ann. Field Conf. Guidebook, p. 246-247.
- LEE, WALLACE, 1916, Geology of the Shawneetown quadrangle in Kentucky: Ky. GS B, Ser. 4, v. 4, pt. 2, 73 p.
- LEIGHTON, M. M., 1925, Glacial history of the Elgin region: Ill. Acad. Sci. Trans. (1924), v. 17, p. 65-71.
- LEIGHTON, M. M., 1926, Notable type Pleistocene section, the Farm Creek exposure near Peoria, Illinois: JG, v. 34, p. 167-174; Ill. GS RI 11.
- LEIGHTON, M. M., 1933, Naming of the subdivisions of the Wisconsin glacial age: Science, v. 77, p. 168.
- LEIGHTON, M. M., 1957, Cary-Mankato-Valders problem: JG, v. 65, p. 108-111.
- LEIGHTON, M. M., 1960, Classification of the Wisconsin glacial stage of the north-central United States: JG, v. 68, p. 529-552.
- LEIGHTON, M. M., and J. A. BROPHY, 1961, Illinoian glaciation in Illinois: JG, v. 69, p. 1-31.
- LEIGHTON, M. M., and G. E. EKBLAW, 1932, Annotated guide across northeastern Illinois, in Glacial geology of the central states: Internat. Geol. Cong., 16th Sess., U.S., 1933, Guidebook 26, Excursion C-3, p. 13-23, 47-51.
- LEIGHTON, M. M., and H. B. WILLMAN, 1949, Late Cenozoic geology of Mississippi Valley, in Itinerary, 2nd Bienn. State Geologists Field Conf.: Ill. GS, 86 p.
- LEIGHTON, M. M., and H. B. WILLMAN, 1950, Loess formations of the Mississippi Valley: JG, v. 58, p. 599-623.
- LEIGHTON, M. M., and H. B. WILLMAN, 1953, Basis of subdivisions of Wisconsin glacial stage in northeastern Illinois, in Itinerary, 4th Bienn. State Geologists Field Conf.: Ill. GS and Ind. GS, p. 1-73.
- LEIGHTON, M. M., G. E. EKBLAW, and C. L. HORBERG, 1948, Physiographic divisions of Illinois: JG, v. 56, p. 16-33; Ill. GS RI 129.
- LEONARD, A. B., and J. C. FRYE, 1960, Wisconsinan molluscan faunas of the Illinois Valley region: Ill. GS C 304, 32 p.
- LEONARD, A. B., J. C. FRYE, and W. H. JOHNSON, 1971, Illinoian and Kansan molluscan faunas of Illinois: Ill. GS C 461, 23 p.
- LESQUEREUX, LEO, 1866, Report on the coal fields of Illinois: GS Ill., v. 1, p. 208-237.
- LEVERETT, FRANK, 1897, Pleistocene features and deposits of the Chicago area: Chicago Acad. Sci., Geol. and Nat. Hist. Survey B 2, 86 p.
- LEVERETT, FRANK, 1898a, Peorian soil and weathered zone (Toronto Formation?): JG, v. 6, p. 244-249.
- LEVERETT, FRANK, 1898b, Weathered zone (Sangamon) between the lowland loess and Illinoian till sheet: JG, v. 6, p. 171-181.

- LEVERETT, FRANK, 1898c, Weathered zone (Yarmouth) between the Illinoian and Kansan till sheets: Iowa Acad. Sci. Proc., v. 5, p. 81-86.
- LEVERETT, FRANK, 1899, Illinois glacial lobe: USGS Mon. 38, 817 p.
- LEVERETT, FRANK, 1929, Moraines and shore lines of the Lake Superior region: USGS Prof. Paper 154, 72 p.
- LIDIAK, E. G., R. F. MARVIN, H. N. THOMAS, and M. N. BASS, 1966, Geochronology of the Midcontinent region, Part 4, Eastern area: J. Geophys. Research, v. 71, p. 5427-5438.
- LINEBACK, J. A., 1966, Deep-water sediments adjacent to the Borden Siltstone (Mississippian) delta in southern Illinois: Ill. GS C 401, 48 p.
- LINEBACK, J. A., 1968a, Subdivisions and depositional environments of New Albany Shale (Devonian-Mississippian) in Indiana: AAPG B, v. 52, p. 1291-1303.
- LINEBACK, J. A., 1968b, Turbidites and other sandstone bodies in the Borden Siltstone (Mississippian) in Illinois: Ill. GS C 425, 29 p.
- LINEBACK, J. A., 1972, Lateral gradation of the Salem and St. Louis Limestones (Middle Mississippian) in Illinois: Ill. GS C 474, 23 p.
- LINEBACK, J. A., and D. L. GROSS, 1972, Studies of Lake Michigan bottom sediments—No. 10. Depositional patterns, facies, and trace element accumulation in the Waukegan Member of the late Pleistocene Lake Michigan Formation in southern Lake Michigan: Ill. GS EGN 58, 25 p.
- LINEBACK, J. A., N. J. AYER, and D. L. GROSS, 1970, Studies of Lake Michigan bottom sediments—No. 3. Stratigraphy of unconsolidated sediments in the southern part of Lake Michigan: Ill. GS EGN 35, 35 p.
- LINEBACK, J. A., D. L. GROSS, and R. P. MEYER, 1972, Studies of Lake Michigan bottom sediments—No. 9. Geologic cross sections derived from seismic profiles and sediment cores from southern Lake Michigan: Ill. GS EGN 54, 43 p.
- LINEBACK, J. A., D. L. GROSS, and R. P. MEYER, 1974, Studies of Lake Michigan bottom sediments—No. 11. Glacial tills under Lake Michigan: Ill. GS EGN 69, 48 p.
- LOCHMAN-BALK, CHRISTINA, 1956, The Cambrian of the middle central interior states of the United States, in *El Sistema Cámbrico su paleogeografía y el problema de su base—symposium*, Pt. 2: 20th Internat. Geol. Congress, p. 447-481.
- LOCHMAN-BALK, CHRISTINA, and J. L. WILSON, 1958, Cambrian biostratigraphy in North America: J. Paleon., v. 32, p. 312-350.
- LOGAN, W. N., 1924, Geological conditions in the oil field of southwestern Indiana: Ind. Dept. Conserv. Pub. 42, 125 p.
- LOWENSTAM, H. A., 1948a, Biostratigraphic studies of the Niagaran inter-reef formations in northeastern Illinois: Ill. State Mus. Sci. Papers, v. 4, 146 p.
- LOWENSTAM, H. A., 1948b, Marine pool, Madison County, Illinois, Silurian reef producer, in *Structure of typical American oil fields*, v. 3: AAPG, p. 153-188; Ill. GS RI 131.
- LOWENSTAM, H. A., 1949, Niagaran reefs in Illinois and their relation to oil accumulation: Ill. GS RI 145, 36 p.
- LOWENSTAM, H. A., 1950, Niagaran reefs of the Great Lakes area: JG, v. 58, p. 430-487.
- LOWENSTAM, H. A., 1957, Niagaran reefs in the Great Lakes area, in *Treatise on marine ecology and paleoecology*: GSA Mem. 67, v. 2, p. 215-248.
- LOWENSTAM, H. A., and E. P. DuBOIS, 1946, Marine pool, Madison County, a new type of oil reservoir in Illinois: Ill. GS RI 114, 30 p.
- LOWENSTAM, H. A., H. B. WILLMAN, and D. H. SWANN, 1956, Niagaran reef at Thornton, Illinois: Ill. GS Guidebook Ser. 4, 19 p.
- LYELL, CHARLES, 1833, Principles of geology: v. 3, London, p. 52-55, 57-58.
- LYELL, CHARLES, 1839, Elements of geology: Pitois-Lerault and Co., Paris, 648 p. [French translation].

## M

- MACCLINTOCK, PAUL, and H. B. WILLMAN, 1959, Geology of the Buda Quadrangle, Illinois: Ill. GS C 275, 29 p.
- McFARLAN, A. C., D. H. SWANN, F. H. WALKER, and EDMUND NOSOW, 1955, Some old Chester problems—Correlations of lower and middle Chester formations of western Kentucky: Ky. GS B 16, 37 p.
- McGEE, W. J., 1891, Pleistocene history of northeastern Iowa: USGS Ann. Rept. 11, pt. 1, p. 189-577.
- McQUEEN, H. S., 1937, Dutchtown, a new Lower Ordovician formation in southeastern Missouri: Mo. GS and Water Resources, 59th Bienn. Rept., 1935-1936, app. 1, 27 p.
- MALHOTRA, RAMESH, 1974, Illinois mineral industry in 1972 and review of preliminary mineral production data for 1973: Ill. GS Ill. Mineral Notes 58, 54 p.
- MALOTT, C. A., 1919, "American Bottoms" region of eastern Greene County, Indiana—a type unit in southern Indiana physiography: Ind. Univ. Studies, v. 6, 61 p.
- MALOTT, C. A., 1925, Upper Chester of Indiana: Ind. Acad. Sci. Proc. (1924), v. 34, p. 103-132.
- MARTIN, J. A., R. D. KNIGHT, and W. C. HAYES, 1961, Ordovician System, in *Stratigraphic succession in Missouri*: Mo. GS, v. 40, p. 20-32.
- MAXEY, G. B., 1964, Hydrostratigraphic units: J. Hydrology, v. 2, p. 124-129.
- MEEK, F. B., and A. H. WORTHEN, 1861a, Age of the goniatite limestone at Rockford, Indiana, and its relation to the "Black Slate" of the western states, and to some of the succeeding rocks above the latter: AJS, v. 32, p. 167-177, 288.
- MEEK, F. B., and A. H. WORTHEN, 1861b, Descriptions of new Paleozoic fossils from Illinois and Iowa: Philadelphia Acad. Nat. Sci. Proc., p. 128-148.
- MEEK, F. B., and A. H. WORTHEN, 1865, Descriptions of new species of Crinoidea, etc. from the Paleozoic rocks of Illinois and some of the adjoining states: Philadelphia Acad. Nat. Sci. Proc., v. 17, p. 143-155.
- MEENTS, W. F., and D. H. SWANN, 1965, Grand Tower Limestone (Devonian) of southern Illinois: Ill. GS C 389, 34 p.
- MEHL, M. G., 1960, Relationships of the base of the Mississippian System in Missouri: Denison Univ. J. Sci. Labs., v. 45, p. 57-107.
- MELLEN, F. F., 1937, Little Bear residuum: Miss. GS B 34, 36 p.
- MILLER, A. M., 1917, Table of geological formations of Kentucky: University Bookstore, 7 p.; reprinted in Miller, 1919, p. 9-15.
- MILLER, A. M., 1919, Geology of Kentucky: Ky. Dept. Geol. and Forestry, Ser. 5, B 2, 392 p.
- MOORE, R. C., 1928, Early Mississippian formations in Missouri: Mo. Bur. Geol. and Mines, v. 21, 283 p.
- MOORE, R. C., 1931, Pennsylvanian cycles in the northern Midcontinent region: Ill. GS B 60, p. 247-257.
- MOORE, R. C., 1933, Historical geology: McGraw-Hill Book Co., Inc., New York, 673 p.
- MOORE, R. C., 1935, Mississippian System in the Upper Mississippi Valley region: Kans. Geol. Soc. 9th Ann. Field Conf. Guidebook, p. 239-245.
- MOORE, R. C., 1949, Introduction to historical geology: McGraw-Hill Book Co., Inc., New York, 582 p.
- MOORE, R. C., et al., 1944, Correlation of Pennsylvanian formations of North America: GSA B, v. 55, p. 657-706.

- MOULTON, G. F., 1926, Areas for further prospecting near the Martinsville Pool, Clark County: Ill. GS Ill. Petroleum 4, 12 p.
- MURCHISON, R. I., 1835, On the Silurian System of rocks: London and Edinburgh Philos. Mag. and Jour. Sci., 3rd Ser., v. 7, p. 46-52.

## N

- NANCE, R. B., 1970, Limestones and phosphatic rocks from the Summum and Liverpool cyclothem in western Illinois: Ill. GS Guidebook Ser. 8, p. 75-83.
- NEWBERRY, J. S., 1873, General geological relations and structure of Ohio: Ohio GS Rept. 1, pt. 1, p. 1-167.
- NEWTON, W. A., and J. M. WELLER, 1937, Stratigraphic studies of Pennsylvanian outcrops in part of southeastern Illinois: Ill. GS RI 45, 31 p.
- NOÉ, A. C., 1925, Pennsylvanian flora of northern Illinois: Ill. GS B 52, 113 p.
- NOÉ, A. C., 1934, Our present knowledge of American coal ball plants: Ill. Acad. Sci. Trans., v. 26, no. 3, p. 103.
- NORTH, W. G., 1969, Middle Devonian strata of southern Illinois: Ill. GS C 441, 45 p.
- NORTON, W. H., 1894, Notes on the lower strata of the Devonian Series in eastern Iowa: Iowa Acad. Sci. Proc. 1, pt. 4, p. 22-24.
- NORTON, W. H., 1895, Geology of Linn County: Iowa GS, v. 4, p. 121-195.
- NORTON, W. H., 1897, Artesian wells of Iowa: Iowa GS, v. 6, p. 113-428.
- NORWOOD, C. J., 1876, Report on the geology of the region adjacent to the Louisville, Paducah, and Southwestern Railroad, with a section: Ky. GS, v. 1, p. 355-488.

## O

- ORR, R. W., 1964, Conodonts from the Devonian Lingle and Alto Formations of southern Illinois: Ill. GS C 361, 28 p.
- OSTROM, M. E., 1967, Paleozoic stratigraphic nomenclature for Wisconsin: Wis. Geol. and Nat. Hist. Survey Inf. C 8, 1 p.
- OWEN, D. D., 1840, Report of a geological exploration of part of Iowa, Wisconsin, and Illinois in 1839: U.S. 28th Cong., 1st sess., Senate Exec. Doc. 239, 161 p.
- OWEN, D. D., 1847, Preliminary report of the geological survey of Wisconsin and Iowa: U.S. General Land Office Rept., 1847, p. 160-173.
- OWEN, D. D., 1852, Report of a geological survey of Wisconsin, Iowa, and Minnesota and incidentally of a portion of Nebraska Territory: Philadelphia, 638 p.
- OWEN, D. D., 1856, Report of the geological survey in Kentucky made during the years 1854 and 1855: Ky. GS B, v. I, Ser. 1, 416 p.

## P

- PAYNE, J. N., 1942, Structure of Herrin (No. 6) coal bed in Macoupin County, eastern Jersey and Greene, southeastern Scott, and southern Morgan and Sangamon Counties: Ill. GS C 88, 46 p.
- PAYNE, J. N., and G. H. CADY, 1944, Structure of Herrin (No. 6) coal bed in Christian and Montgomery Counties and adjacent parts of Fayette, Macon, Sangamon, and Shelby Counties: Ill. GS C 105, 57 p.
- PENROSE, R. A. F., JR., 1891a, Batesville region of Arkansas: Ark. GS Ann. Rept. 1890, v. 1, p. 102-174.
- PENROSE, R. A. F., JR., 1891b, Manganese, its uses, ores, and deposits: Ark. GS Ann. Rept. 1890, 642 p.
- PEPPERS, R. A., 1964, Spores in strata of late Pennsylvanian cyclothem in the Illinois Basin: Ill. GS B 90, 89 p.

- PEPPERS, R. A., 1970, Correlation and palynology of coals in the Carbondale and Spoon Formations (Pennsylvanian) of the northeastern part of the Illinois Basin: Ill. GS B 93, 173 p.
- PERRY, T. G., 1962, Spechts Ferry (Middle Ordovician) bryozoan fauna from Illinois, Wisconsin, and Iowa: Ill. GS C 326, 36 p.
- PHILLIPS, J., 1840, Penny cyclopedia: v. 17, p. 153-154.
- PIERCE, W. G., and W. H. COURTIER, 1937, Geology and coal resources of the southeastern Kansas coal field: Kans. GS B 24, 122 p.
- PISKIN, KEMAL, and R. E. BERGSTROM, 1967, Glacial drift in Illinois: Thickness and character: Ill. GS C 416, 33 p.
- POTTER, P. E., 1955, Petrology and origin of the Lafayette Gravel: JG, v. 63, p. 1-38, 115-132.
- POTTER, P. E., 1962a, Late Mississippian sandstones of Illinois: Ill. GS C 340, 36 p.
- POTTER, P. E., 1962b, Shape and distribution patterns of Pennsylvanian sand bodies in Illinois: Ill. GS C 339, 35 p.
- POTTER, P. E., 1963, Late Paleozoic sandstones of the Illinois Basin: Ill. GS RI 217, 92 p.
- POTTER, P. E., and J. S. OLSON, 1954, Variance components of cross-bedding direction in some basal Pennsylvanian sandstones of the Eastern Interior Basin—geological application: JG, v. 62, p. 50-73.
- POTTER, P. E., and J. A. SIMON, 1961, Anvil Rock Sandstone and channel cutouts of Herrin (No. 6) Coal in west-central Illinois: Ill. GS C 314, 12 p.
- POWERS, W. E., and G. E. EKBLAW, 1940, Glaciation of Grays Lake, Illinois, Quadrangle: GSA B, v. 51, p. 1329-1335.
- PRYOR, W. A., 1960, Cretaceous sedimentation in upper Mississippi Embayment: AAPG B, v. 44, p. 1473-1504; Ill. GS Reprint 1960-J.
- PRYOR, W. A., and H. D. GLASS, 1961, Cretaceous-Tertiary clay mineralogy of the upper Mississippi Embayment: J Sed. Petrology, v. 31, p. 36-51; Ill. GS Reprint 1961-M.
- PRYOR, W. A., and C. A. ROSS, 1962, Geology of the Illinois parts of the Cairo, La Center, and Thebes Quadrangles: Ill. GS C 332, 39 p.

## R

- RAASCH, G. O., 1951, Revision of Croixan dikelocephalids: Ill. Acad. Sci. Trans., v. 44, p. 137-151; Ill. GS C 179.
- READ, C. B., and S. H. MAMAY, 1964, Upper Paleozoic floral zones and floral provinces of the United States: USGS Prof. Paper 454-K, p. K1-K35.
- REXRoad, C. B., and R. C. BURTON, 1961, Conodonts from the Kinkaid Formation (Chester) in Illinois: J Paleon., v. 35, p. 1143-1158; Ill. GS Reprint 1962-B.
- ROSS, C. A., 1962a, Early Llandoveryan (Silurian) graptolites from the Edgewood Formation, northeastern Illinois: J Paleon., v. 36, no. 6, p. 1383-1386; Ill. GS Reprint 1963-A.
- ROSS, C. A., 1962b, Silurian monograptids from Illinois: Paleon., v. 5, p. 59-72; Ill. GS Reprint 1962-N.
- ROSS, C. A., 1963, Structural framework of southernmost Illinois: Ill. GS C 351, 27 p.
- ROSS, C. A., 1964, Geology of the Paducah and Smithland Quadrangles in Illinois: Ill. GS C 360, 32 p.
- RUBEY, W. W., 1952, Geology and mineral resources of the Hardin and Brussels Quadrangles: USGS Prof. Paper 218, 179 p.
- RUCH, R. R., E. J. KENNEDY, and N. F. SHIMP, 1970, Studies of Lake Michigan bottom sediments—No. 4. Distribution of arsenic in unconsolidated sediments from southern Lake Michigan: Ill. GS EGN 37, 16 p.
- RUDMAN, A. J., C. H. SUMMERSON, and W. J. HINZE, 1965, Geology of basement in midwestern United States: AAPG B, v. 49, p. 894-904.

RUSNAK, G. A., 1957, Fabric and petrologic study of the Pleasantview Sandstone: *J. Sed. Petrology*, v. 27, p. 41-55; disc. p. 198-201, 346-350.

## S

- SAFFORD, J. M., 1864, On the Cretaceous and superior formations of west Tennessee: *AJS*, v. 37, p. 360-372.
- SAFFORD, J. M., 1869, *Geology of Tennessee*: S. C. Mercer, Nashville, Tenn., 550 p.
- SALISBURY, R. D., 1892, On the northward and eastward extension of the pre-Pleistocene gravels of the Mississippi basin: *GSA B*, v. 3, p. 183-186.
- SARDESON, F. W., 1907, *Galena Series*: *GSA B*, v. 18, p. 179-194.
- SAVAGE, T. E., 1908, On the lower Paleozoic stratigraphy of southwestern Illinois: *AJS*, v. 25, p. 431-443; expanded in *Ill. GS B* 8, p. 103-116.
- SAVAGE, T. E., 1909, Ordovician and Silurian formations in Alexander County, Illinois: *AJS*, v. 28, p. 509-519.
- SAVAGE, T. E., 1910, Faunal succession and the correlation of the pre-Devonian formations of southern Illinois: *Ill. GS B* 16, p. 302-341.
- SAVAGE, T. E., 1912, Channahon and Essex Limestones in Illinois: *Ill. Acad. Sci. Trans.*, v. 4, p. 97-103.
- SAVAGE, T. E., 1913, Stratigraphy and paleontology of the Alexandrian Series in Illinois and Missouri, Pt. 1: *Ill. GS Extract B* 23, 124 p.; 1917, *Ill. GS B* 23, p. 67-160.
- SAVAGE, T. E., 1914, Relations of the Alexandrian Series in Illinois and Missouri to the Silurian section of Iowa: *AJS*, v. 38, p. 28-37.
- SAVAGE, T. E., 1916, Alexandrian rocks of northeastern Illinois and eastern Wisconsin: *GSA B*, v. 27, p. 305-324.
- SAVAGE, T. E., 1917, Thebes sandstone and Orchard Creek shale and their faunas in Illinois: *Ill. Acad. Sci. Trans.*, v. 10, p. 261-275.
- SAVAGE, T. E., 1920, Devonian formations of Illinois: *AJS*, v. 49, p. 169-182.
- SAVAGE, T. E., 1921a, Geology and mineral resources of the Avon and Canton Quadrangles: *Ill. GS B* 38, p. 209-271.
- SAVAGE, T. E., 1921b, New species of Devonian fossils from western Illinois: *Ill. Acad. Sci. Trans.*, v. 14, p. 197-206.
- SAVAGE, T. E., 1925a, Correlation of the Maquoketa and Richmond rocks of Iowa and Illinois: *Ill. Acad. Sci. Trans.*, v. 17, p. 233-247.
- SAVAGE, T. E., 1925b, Oriskany rocks in Illinois: *AJS*, v. 10, p. 139-144.
- SAVAGE, T. E., 1926, Silurian rocks of Illinois: *GSA B*, v. 37, p. 513-533.
- SAVAGE, T. E., 1927, Significant breaks and overlaps in the Pennsylvanian rocks of Illinois: *AJS*, v. 14, p. 307-316.
- SAVAGE, T. E., 1942, in *Correlation of the Silurian formations of North America*: *GSA B*, v. 53, p. 533-538, plate 1.
- SAVAGE, T. E., and C. S. ROSS, 1916, Age of the iron ore in eastern Wisconsin: *AJS*, v. 41, p. 187-193.
- SAVAGE, T. E., and J. A. UDDEN, 1921, Geology and mineral resources of the Edgington and Milan Quadrangles: *Ill. GS B* 38, p. 115-208.
- SCHIMPER, W. P., 1874, *Traite de paleontologie vegetale*: v. 3, p. 680-682.
- SCHLEICHER, J. A., and J. K. KUHN, 1970, Studies of Lake Michigan bottom sediments—No. 5. Phosphorus content in unconsolidated sediments from southern Lake Michigan: *Ill. GS EGN* 39, 15 p.
- SCHOOLCRAFT, H. R., 1825, *Travels in the central portions of the Mississippi Valley*; comprising observations on its mineral geography: Collins and Hannay, New York.
- SCHUCHERT, CHARLES, and JOSEPH BARRELL, 1914, Revised geologic time-table for North America: *AJS*, v. 38, p. 1-27.
- SCHWALB, H. R., 1955, Geneva (Middle Devonian) Dolomite in Illinois: *Ill. GS C* 204, 7 p.
- SCOTT, A. J., and CHARLES COLLINSON, 1961, Conodont faunas from the Louisiana and McCraney Formations of Illinois, Iowa, and Missouri, in *Kans. Geol. Soc. Guidebook, 26th Field Conf.*, northeastern Missouri and west-central Illinois: *Mo. GS RI* 27, p. 110-141; *Ill. GS Reprint* 1961-V.
- SEARIGHT, T. K., and W. H. SMITH, 1969, Strippable coal reserves of Illinois, Part 5B: *Ill. GS C* 439, 22 p.
- SEARIGHT, W. V., et al., 1953, Classification of the Desmoinesian (Pennsylvanian) of the northern Mid-Continent: *AAPG B*, v. 37, p. 2747-2749.
- SEDGWICK, A., 1835 [abs.]: *Edinburgh New Philos. J*, v. 19, p. 390.
- SEDGWICK, A., 1838, *Geological Soc. London Proc.*, v. 2, no. 58, p. 84-85.
- SEDGWICK, A., and R. I. MURCHISON, 1839, *Geol. Soc. London Proc.*, v. 3, no. 63, p. 121-123.
- SHAFFER, P. R., 1956, Farmdale drift in northwestern Illinois: *Ill. GS RI* 198, 25 p.
- SHAVER, R. H., et al., 1970, *Compendium of rock-unit stratigraphy in Indiana*: *Ind. GS B* 43, 229 p.
- SHAW, E. W., and T. E. SAVAGE, 1912, Murphysboro and Herrin Quadrangles: *USGS Geol. Atlas Folio* 185, 15 p.
- SHAW, E. W., and T. E. SAVAGE, 1913, Tallula and Springfield Quadrangles: *USGS Geol. Atlas Folio* 188, 12 p.
- SHAW, JAMES, 1873, *Geology of northwestern Illinois*: *GS Ill.*, v. 5, p. 1-94.
- SHEPARD, C. U., 1838, *Geology of upper Illinois*: *AJS*, v. 34, p. 134-161.
- SHIMK, BOHUMIL, 1909, Aftonian sands and gravels in western Iowa: *GSA B*, v. 20, p. 399-408.
- SHIMP, N. F., H. V. LELAND, and W. A. WHITE, 1970, Studies of Lake Michigan bottom sediments—No. 2. Distribution of major, minor, and trace constituents in unconsolidated sediments from southern Lake Michigan: *Ill. GS EGN* 32, 19 p.
- SHIMP, N. F., J. A. SCHLEICHER, R. R. RUCH, D. B. HECK, and H. V. LELAND, 1971, Studies of Lake Michigan bottom sediments—No. 6. Trace element and organic carbon accumulation in the most recent sediments of southern Lake Michigan: *Ill. GS EGN* 41, 25 p.
- SHUMARD, B. F., 1860, Observations on the geology of the County of Ste. Genevieve: *St. Louis Acad. Sci. Trans.*, v. 1, p. 404-415.
- SIEVER, RAYMOND, 1951, Mississippian-Pennsylvanian unconformity in southern Illinois: *AAPG B*, v. 35, p. 542-581; *Ill. GS RI* 152.
- SIEVER, RAYMOND, 1956, Correlation chart of classification of the Pennsylvanian rocks of Illinois as of 1956, in *Ill. GS C* 217, pl. 1.
- SIEVER, RAYMOND, 1957, Pennsylvanian sandstones of the Eastern Interior Coal Basin: *J. Sed. Petrology*, v. 27, p. 227-250; *Ill. GS Reprint* 1957-N.
- SIMONDS, F. W., 1891, *Geology of Washington County, Arkansas*: *Ark. GS Ann. Rept.* 1888, v. 4, p. 1-148.
- SLOSS, L. L., 1963, Sequences in the cratonic interior of North America: *GSA B*, v. 74, p. 93-114.
- SLOSS, L. L., W. C. KRUMBEIN, and E. C. DAPPLES, 1949, Integrated facies analysis, in *Sedimentary facies in geologic history*: *GSA Mem.* 39, p. 91-123.
- SMITH, E. A., 1890, Geological structure and description of the valley regions adjacent to the Cahaba coal field, in *Report on the Cahaba coal field*: *Ala. GS*, pt. 2, p. 137-180.
- SMITH, E. A., and L. C. JOHNSON, 1887, Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama Rivers: *USGS B* 43, 189 p.
- SMITH, G. D., 1942, Illinois loess—variations in its properties and distribution, a pedologic interpretation: *Univ. Ill. Agr. Exp. Sta. B* 490, p. 139-184.

- SMITH, N. M., 1965, Sanders Group and subjacent Muldraugh Formation (Mississippian) in Indiana: Ind. GS Rept. Prog. 29, 20 p.
- SMITH, W. H., 1970, Lithology and distribution of the Francis Creek Shale in Illinois: Ill. GS Guidebook Ser. 8, p. 34.
- SMITH, W. H., and N. R. O'BRIEN, 1965, Middle and late Pennsylvanian flint clays: J Sed. Petrology, v. 35, p. 610-618; Ill. GS Reprint 1965-T.
- STAINBROOK, M. A., 1935, Stratigraphy of the Devonian System of the Upper Mississippi Valley: Kans. Geol. Soc. Guidebook, 9th Ann. Field Conf., p. 248-260.
- STAUFFER, C. R., and G. A. THIEL, 1941, Paleozoic and related rocks of southeastern Minnesota: Minn. GS B 29, 261 p.
- STEARNS, R. G., 1958, Cretaceous, Paleocene, and Lower Eocene geologic history of the northern Mississippi Embayment: GSA B. v. 68, p. 1077-1100.
- STEPHENSON, L. W., 1914, Cretaceous deposits of the eastern Gulf region and species of *Exogyra* from the eastern Gulf regions and the Carolinas: USGS Prof. Paper 81, 77 p.
- STEVENSON, D. L., 1964, Carper sand oil production in St. James, Wilberton, and St. Paul pools, Fayette County, Illinois: Ill. GS C 362, 12 p.
- STOCKDALE, P. B., 1929, Stratigraphic units of the Harrodsburg Limestone: Ind. Acad. Sci. Proc., 1928, v. 38, p. 233-242.
- STOCKDALE, P. B., 1939, Lower Mississippian rocks of the east-central interior: GSA Special Paper 22, 248 p.
- STONEHOUSE, H. R., and G. M. WILSON, 1955, Faults and other structures in southern Illinois—a compilation: Ill. GS C 195, 4 p.
- SUMMERSON, C. H., and D. H. SWANN, 1970, Patterns of Devonian sand on the North American craton and their interpretation: GSA B, v. 81, p. 469-490; Ill. GS Reprint 1970-D.
- SUTER, MAX, R. E. BERGSTROM, H. F. SMITH, G. H. EMRICH, W. C. WALTON, and T. E. LARSON, 1959, Preliminary report on ground-water resources of the Chicago region, Illinois: Ill. GS and Ill. Water Survey Coop. Ground-Water Rept. 1, 89 p.
- SUTTON, A. H., 1934, Stratigraphy of the Okaw in southwestern Illinois: JG, v. 42, p. 621-629.
- SUTTON, A. H., 1935, Stratigraphy of the Silurian System of the upper Mississippi Valley: Kans. Geol. Soc. Guidebook, 9th Ann. Field Conf., p. 268-280.
- SUTTON, A. H., and J. M. WELLER, 1932, Lower Chester correlation in western Kentucky and Illinois: JG, v. 40, p. 430-442.
- SWALLOW, G. C., 1855, Geology of Missouri: Mo. GS 2nd Ann. Rept., p. 59-170.
- SWALLOW, G. C., 1858, Explanations of the geological map of Missouri and a section of its rocks: AAAS Proc. 11, pt. 2, p. 1-21.
- SWANN, D. H., 1951, Waltersburg Sandstone oil pools of lower Wabash area, Illinois and Indiana: AAPG B, v. 35, p. 2561-2581; Ill. GS RI 160.
- SWANN, D. H., 1963, Classification of Genevievean and Chesterian (Late Mississippian) rocks of Illinois: Ill. GS RI 216, 91 p.
- SWANN, D. H., 1964, Late Mississippian rhythmic sediments of Mississippi Valley: AAPG B, v. 48, p. 637-658; Ill. GS Reprint 1964-G.
- SWANN, D. H., 1968, A summary geologic history of the Illinois Basin, in Geology and petroleum production of the Illinois Basin, a symposium: Ill. and Ind.-Ky. Geol. Soc., p. 3-22.
- SWANN, D. H., and ELWOOD ATHERTON, 1948, Subsurface correlations of lower Chester strata of the Eastern Interior Basin, in Symposium on problems of Mississippian stratigraphy and correlation: JG, v. 56, p. 269-287; Ill. GS RI 135.
- SWANN, D. H., and H. B. WILLMAN, 1961, Megagroups in Illinois: AAPG B, v. 45, p. 471-483; Ill. GS Reprint 1961-N.
- SWANN, D. H., J. A. LINEBACK, and EUGENE FRUND, 1965, Borden Siltstone (Mississippian) delta in southwestern Illinois: Ill. GS C 386, 20 p.
- SWARTZ, C. K., et al., 1942, Correlation of the Silurian formations of North America: GSA B, v. 53, p. 533-538.

## T

- TAFF, J. A., 1902, Atoka Quadrangle: USGS Geol. Atlas Folio 79, 8 p.
- TAFF, J. A., and G. I. ADAMS, 1900, Geology of the eastern Choctaw coal field, Indian Territory: USGS 21st Ann. Rept., pt. 2, p. 257-311.
- TAYLOR, E. F., and G. H. CADY, 1944, Structure of the Millersville Limestone in the north part of the Illinois Basin: Ill. GS RI 93, p. 22-26.
- TEMPLETON, J. S., 1950, Mt. Simon Sandstone in northern Illinois: Ill. Acad. Sci. Trans., v. 43, p. 151-159.
- TEMPLETON, J. S., and H. B. WILLMAN, 1963, Champlainian Series (Middle Ordovician) in Illinois: Ill. GS B 89, 260 p.
- THOMPSON, M. L., and R. H. SHAVER, 1964, Early Pennsylvanian microfaunas of the Illinois Basin: Ill. Acad. Sci. Trans., v. 57, p. 3-23; Ill. GS Reprint 1964-E.
- THOMPSON, M. L., R. H. SHAVER, and E. A. RIGGS, 1959, Early Pennsylvanian fusulinids and ostracodes of the Illinois Basin: J Paleon., v. 33, p. 770-792; Ill. GS Reprint 1959-P.
- THWAITES, F. T., 1923, Paleozoic rocks found in deep wells in Wisconsin and northern Illinois: JG, v. 31, p. 529-555.
- THWAITES, F. T., 1927, Stratigraphy and geologic structure of northern Illinois: Ill. GS RI 13, 49 p.
- THWAITES, F. T., 1943, Pleistocene of part of northeastern Wisconsin: GSA B, v. 54, p. 87-144; abs. in Proc., 1936 [published 1937], p. 108-109.
- THWAITES, F. T., and KENNETH BERTRAND, 1957, Pleistocene geology of the Door Peninsula, Wisconsin: GSA B, v. 68, p. 831-879.
- TIPPIE, F. E., 1945, Rosiclare-Fredonia contact in and adjacent to Hardin and Pope Counties, Illinois: AAPG B, v. 29, p. 1654-1663; Ill. GS RI 112.
- TROWBRIDGE, A. C., and G. I. ATWATER, 1934, Stratigraphic problems in the upper Mississippi Valley: GSA B, v. 45, p. 21-80.
- TWENHOFEL, W. H., G. O. RAASCH, and F. T. THWAITES, 1935, Cambrian strata of Wisconsin: GSA B, v. 46, p. 1687-1744.
- TWENHOFEL, W. H., et al., 1954, Correlation of the Ordovician formations of North America: GSA B, v. 65, p. 247-298.

## U

- UDDEN, J. A., 1899, Sweetland Creek beds: JG, v. 7, p. 65-78.
- UDDEN, J. A., 1912, Geology and mineral resources of the Peoria Quadrangle, Illinois: USGS B 506, 103 p.
- ULRICH, E. O., 1904, in E. R. Buckley and H. A. Buehler, Quarrying industry of Missouri: Mo. Bur. Geol. and Mines, v. 2, 371 p.
- ULRICH, E. O., 1907, in A. H. Purdue, Cave-sandstone deposits of the southern Ozarks: GSA B, v. 18, p. 251-256.
- ULRICH, E. O., 1911, Revision of the Paleozoic systems: GSA B, v. 22, p. 281-680.
- ULRICH, E. O., and W. S. T. SMITH, 1905, Lead, zinc, and fluorspar deposits of western Kentucky: USGS Prof. Paper 36, 218 p.

## V

- VAN EYSINGA, F. W. B., 1972, Geological time table: Chart (2nd Ed.), Elsevier Publishing Co., Amsterdam, The Netherlands.
- VAN TUYL, F. M., 1925, Stratigraphy of the Mississippian formations of Iowa: Iowa GS, v. 30, p. 33-349.
- VANUXEM, LARDNER, 1838, Second annual report of the geological survey of the third district of the state of New York: N.Y. GS Ann. Rept. 2, p. 253-286.
- VANUXEM, LARDNER, 1842, Geology of New York, pt. 3, comprising the survey of the third geological district: Albany, 306 p.

## W

- WALCOTT, C. D., 1914, Cambrian geology and paleontology: Smithsonian Misc. Coll., v. 57, p. 345-412.
- WANLESS, H. R., 1929, Geology and mineral resources of the Alexis Quadrangle: Ill. GS B 57, 230 p.
- WANLESS, H. R., 1931a, Pennsylvanian cycles in western Illinois: Ill. GS B 60, p. 179-193.
- WANLESS, H. R., 1931b, Pennsylvanian section in western Illinois: GSA B, v. 42, p. 801-812.
- WANLESS, H. R., 1938, Stratigraphy of the Caseyville and Tradewater Groups of Illinois: Ill. GS unpublished manuscript HRW-12, 76 p.
- WANLESS, H. R., 1939, Pennsylvanian correlations in the Eastern Interior and Appalachian coal fields: GSA Special Paper 17, 130 p.
- WANLESS, H. R., 1955, Pennsylvanian rocks of Eastern Interior Basin: AAPG B, v. 39, p. 1753-1820 (see 1962).
- WANLESS, H. R., 1956, Classification of the Pennsylvanian rocks of Illinois as of 1956: Ill. GS C 217, 14 p.
- WANLESS, H. R., 1957, Geology and mineral resources of the Beardstown, Glasford, Havana, and Vermont Quadrangles: Ill. GS B 82, 233 p.
- WANLESS, H. R., 1958, Pennsylvanian faunas of the Beardstown, Glasford, Havana, and Vermont Quadrangles: Ill. GS RI 205, 59 p.
- WANLESS, H. R., 1962, Pennsylvanian rocks of Eastern Interior Basin, in Pennsylvanian System in the United States—A symposium: AAPG. Originally published 1955; reprinted with minor revisions.
- WANLESS, H. R., 1963, Pennsylvanian, in *Lexique stratigraphique international—Termes stratigraphiques majeurs*: 20th Internat. Geol. Cong., Stratigraphic Commission, Paris, France, 64 p.
- WANLESS, H. R., 1965, Environmental interpretation of coal distribution in the eastern and central United States: Ill. Mining Institute Proc., p. 19-35.
- WANLESS, H. R., and J. M. WELLER, 1932, Correlation and extent of Pennsylvanian cyclothems: GSA B, v. 43, p. 1003-1016.
- WANLESS, H. R., J. R. BAROFFIO, and P. C. TRESCOTT, 1969, Conditions of deposition of Pennsylvanian coal beds: GSA Special Paper 114, p. 105-142.
- WANLESS, H. R., J. B. TUBB, JR., D. E. GEDNETZ, and J. L. WEINER, 1963, Mapping sedimentary environments of Pennsylvanian cycles: GSA B, v. 74, p. 437-486.
- WASCHER, H. L., R. P. HUMBERT, and J. G. CADY, 1948, Loess in the southern Mississippi Valley—Identification and distribution of the loess sheets: Soil Sci. Soc. America Proc. (1947), v. 12, p. 389-399.
- WEISS, M. P., 1955, Some Ordovician brachiopods from Minnesota and their stratigraphic relations: J Paleon., v. 29, p. 759-774.
- WEISS, M. P., and C. E. NORMAN, 1960, American Upper Ordovician Standard, II. Development of stratigraphic classification of Ordovician rocks in the Cincinnati region: Ohio GS Inf. C 26, 14 p.
- WELLER, J. M., 1930, Cyclical sedimentation of the Pennsylvanian Period and its significance: JG, v. 38, p. 97-135.
- WELLER, J. M., 1931, Conception of cyclical sedimentation during the Pennsylvanian Period: Ill. GS B 60, p. 163-177.
- WELLER, J. M., 1936, Grassy Creek shales: Ill. Acad. Sci. Trans. (1935), v. 28, p. 191-192.
- WELLER, J. M., 1939, Mississippian System: Kans. Geol. Soc. Guidebook, 13th Ann. Field Conf., southwestern Illinois and southeastern Missouri, p. 131-137.
- WELLER, J. M., 1940, Geology and oil possibilities of extreme southern Illinois: Ill. GS RI 71, 71 p.
- WELLER, J. M., 1944a, Devonian System in southern Illinois: Ill. GS B 68, p. 89-102.
- WELLER, J. M., 1944b, Devonian correlations in Illinois and surrounding states—a summary: Ill. GS B 68, p. 205-213.
- WELLER, J. M., and A. H. BELL, 1936, Geology and oil and gas possibilities of parts of Marion and Clay Counties, with a discussion of the central portion of the Illinois Basin: Ill. GS RI 40, 54 p.
- WELLER, J. M., and G. E. EKBLAW, 1940, Preliminary geologic map of parts of the Alto Pass, Jonesboro, and Thebes Quadrangles, Union, Alexander, and Jackson Counties: Ill. GS RI 70, 26 p.
- WELLER, J. M., and A. H. SUTTON, 1940, Mississippian border of Eastern Interior Basin: AAPG B, v. 24, p. 765-858; Ill. GS RI 62.
- WELLER, J. M., R. M. GROGAN, and F. E. TIPPIC, 1952, Geology of the fluorspar deposits of Illinois: Ill. GS B 76, 147 p.
- WELLER, J. M., L. G. HENBEST, and C. O. DUNBAR, 1942a, Stratigraphy of the fusuline-bearing beds of Illinois: Ill. GS B 67, p. 9-34.
- WELLER, J. M., H. R. WANLESS, L. M. CLINE, and D. G. STOOKEY, 1942b, Interbasin Pennsylvanian correlations, Illinois and Iowa: AAPG B, v. 26, p. 1585-1593.
- WELLER, J. M., et al., 1945, Geologic map of Illinois: Ill. GS.
- WELLER, J. M., et al., 1948, Correlation of the Mississippian formations of North America: GSA B, v. 59, p. 91-196.
- WELLER, STUART, 1897, Correlation of the Devonian faunas in southern Illinois: JG, v. 5, p. 625-635.
- WELLER, STUART, 1906a, Geological map of Illinois: Ill. GS B 1, 24 p.
- WELLER, STUART, 1906b, Kinderhook faunal studies—4. Fauna of the Glen Park limestone: St. Louis Acad. Sci. Trans., v. 16, p. 435-471.
- WELLER, STUART, 1907, Geological map of Illinois (2nd Ed.): Ill. GS B 6, 34 p.
- WELLER, STUART, 1913, Stratigraphy of the Chester Group in southwestern Illinois: Ill. Acad. Sci. Trans., v. 6, p. 118-129.
- WELLER, STUART, 1914, Mississippian Brachiopoda of the Mississippi Valley Basin: Ill. GS Mon. 1, pt. 1, 508 p.; pt. 2, 187 p.
- WELLER, STUART, 1920, Chester Series in Illinois: JG, v. 28, p. 281-303, 395-416.
- WELLER, STUART, 1926, Faunal zones in the standard Mississippian section: JG, v. 34, p. 320-335.
- WELLER, STUART, and STUART ST. CLAIR, 1928, Geology of Ste. Genevieve County, Missouri: Mo. Bur. Geol. and Mines, v. 22, 352 p.
- WELLER, STUART, and J. M. WELLER, 1939, Preliminary geological maps of the pre-Pennsylvanian formations in part of southwestern Illinois: Ill. GS RI 59, 15 p.
- WELLER, STUART, CHARLES BUTTS, L. W. CURRIER, and R. D. SALISBURY, 1920, Geology of Hardin County and the adjoining part of Pope County: Ill. GS B 41, 402 p.
- WHEELER, H. A., 1896, Clay deposits: Mo. GS, v. 11, 1st Ser., 622 p.

- WHITE, C. A., 1870, Geology of southwestern Iowa: Iowa GS, v. 1, p. 296-381.
- WHITE, DAVID, 1909, Paleobotanical work in Illinois in 1908: Ill. GS B 14, p. 293-295.
- WHITE, G. W., 1969, Early geological observations in the American Midwest, in *Toward a history of geology*: Mass. Inst. Tech. Press, Cambridge, Mass., p. 415-425.
- WHITE, G. W., and B. O. SLANKER, 1962, Early geology in the Mississippi Valley: Univ. Ill., Urbana, 26 p.
- WHITE, W. A., A. H. BEAVERS, H. L. WASCHER, G. M. WILSON, and J. B. DROSTE, 1958, Itinerary of field trip for Fifth National Clay Conference, Oct. 8, 1956: Natl. Research Council Pub. 566, p. 1-3; Ill. GS Reprint 1958-BB.
- WHITING, L. L., and D. L. STEVENSON, 1965, Sangamon Arch: Ill. GS C 383, 20 p.
- WILLIAMS, H. S., 1891, Correlation papers—Devonian and Carboniferous: USGS B 80, 279 p.
- WILLIAMS, J. S., 1943, Stratigraphy and fauna of the Louisiana Limestone of Missouri: USGS Prof. Paper 203, 133 p.
- WILLMAN, H. B., 1939, Covel Conglomerate, a guide bed in the Pennsylvanian of northern Illinois: Ill. Acad. Sci. Trans., v. 32, p. 174-176; Ill. GS C 60, p. 8-10.
- WILLMAN, H. B., 1943, High-purity dolomite in Illinois: Ill. GS RI 90, 89 p.
- WILLMAN, H. B., 1962, Silurian strata of northeastern Illinois, and Descriptions of stops second day, in *Silurian rocks of the southern Lake Michigan area*: Mich. Basin Geol. Soc. Ann. Field Conf., p. 61-67, 81-96; Ill. GS Reprint 1962-M.
- WILLMAN, H. B., 1971, Summary of the geology of the Chicago area: Ill. GS C 460, 77 p.
- WILLMAN, H. B., 1973, Rock stratigraphy of the Silurian System in northeastern and northwestern Illinois: Ill. GS C 479, 55 p.
- WILLMAN, H. B., and J. C. FRYE, 1958, Problems of Pleistocene geology in the greater St. Louis area: GSA Guidebook, St. Louis mtg., 2nd Field Trip, p. 9-19.
- WILLMAN, H. B., and J. C. FRYE, 1970, Pleistocene stratigraphy of Illinois: Ill. GS B 94, 204 p.
- WILLMAN, H. B., and J. N. PAYNE, 1942, Geology and mineral resources of the Marseilles, Ottawa, and Streator Quadrangles: Ill. GS B 66, 388 p.
- WILLMAN, H. B., and J. N. PAYNE, 1943, Early Ordovician strata along Fox River in northern Illinois: JG, v. 51, p. 531-541.
- WILLMAN, H. B., and J. S. TEMPLETON, 1951, Cambrian and Lower Ordovician exposures in northern Illinois: Ill. Acad. Sci. Trans., v. 44, p. 109-125; Ill. GS C 179, 1952.
- WILLMAN, H. B., H. D. GLASS, and J. C. FRYE, 1963, Mineralogy of glacial tills and their weathering profiles in Illinois. Pt. 1—Glacial tills: Ill. GS C 347, 55 p.
- WILLMAN, H. B., H. D. GLASS, and J. C. FRYE, 1966, Mineralogy of glacial tills and their weathering profiles in Illinois. Pt. 2—Weathering profiles: Ill. GS C 400, 76 p.
- WILLMAN, H. B., A. B. LEONARD, and J. C. FRYE, 1971, Farmdalian lake deposits and faunas in northern Illinois: Ill. GS C 467, 12 p.
- WILLMAN, H. B., H. A. LOWENSTAM, and L. E. WORKMAN, 1950, Field conference on Niagara reefs in the Chicago region: Ill. GS Guidebook Ser. 1, 23 p.
- WILLMAN, H. B., D. H. SWANN, and J. C. FRYE, 1958, Stratigraphic policy of the Illinois State Geological Survey: Ill. GS C 249, 14 p.
- WILLMAN, H. B., et al., 1967, Geologic map of Illinois: Ill. GS.
- WILMARTH, M. G., 1925, Geologic time classification of the United States Geological Survey compared with other classifications: USGS B 769, 138 p.
- WILSON, A. E., 1938, Legend on Ottawa sheet (east half): Canada GS.
- WILSON, A. E., 1946, Geology of the Ottawa-St. Lawrence lowland, Ontario and Quebec: Canada GS Mem. 241, 65 p.
- WINCHELL, ALEXANDER, 1869, On the geological age and equivalents of the Marshall group: Am. Philos. Soc., Proc., v. 11, p. 57-82.
- WINCHELL, ALEXANDER, 1872, Report of a geological survey of the vicinity of Belleplaine, Scott County, Minnesota: St. Paul, Minn., 16 p.
- WINCHELL, N. H., 1873, Potsdam Sandstone: Minn. Geol. and Nat. Hist. Survey 1st Ann. Rept. (1872), p. 68-80.
- WINCHELL, N. H., 1874, Second annual report for the year 1873: Minn. Geol. and Nat. Hist. Survey, p. 73-219.
- WINCHELL, N. H., 1886, Revision of the stratigraphy of the Cambrian in Minnesota: Minn. Geol. and Nat. Hist. Survey 14th Ann. Rept. (1885), p. 325-337.
- WINCHELL, N. H., 1900, Geologic map of Minnesota: Minn. GS.
- WINCHELL, N. H., and E. O. ULRICH, 1897, Lower Silurian deposits of the Upper Mississippi Province: Minn. GS, Paleontology, v. 3, pt. 2, p. lxxxiii-cxxvii.
- WINSLOW, ARTHUR, 1894, Lead and zinc deposits—Pt. 1: Mo. GS, v. 6, 387 p.
- WINSLOW, M. R., 1959, Upper Mississippian and Pennsylvanian megaspores and other plant microfossils from Illinois: Ill. GS B 86, 135 p.
- WOOSTER, L. C., 1882, Geology of the lower St. Croix district: Wis. GS, v. 4, p. 99-159.
- WORKMAN, L. E., 1935, Mississippi Valley geologic cross section: Kans. Geol. Soc. Guidebook, 9th Ann. Field Conf., p. 362-367, 370, fig. 232.
- WORKMAN, L. E., 1944, Subsurface geology of the Devonian System in Illinois: Ill. GS B 68, p. 189-199.
- WORKMAN, L. E., 1950, Neda Formation in northeastern Illinois: Ill. Acad. Sci. Trans., v. 43, p. 176-182; Ill. GS C 170, p. 176-182.
- WORKMAN, L. E., and A. H. BELL, 1948, Deep drilling and deeper oil possibilities in Illinois: AAPG B, v. 32, p. 2041-2062; Ill. GS RI 139.
- WORKMAN, L. E., and TRACEY GILLETTE, 1956, Subsurface stratigraphy of the Kinderhook Series in Illinois: Ill. GS RI 189, 46 p.
- WORTHEN, A. H., 1860, Remarks on the discovery of a terrestrial flora in the Mountain Limestone of Illinois [abs.]: AAAS Proc., v. 13, p. 312-313.
- WORTHEN, A. H., 1866, Geology: GS Ill., v. 1, 504 p.
- WORTHEN, A. H., 1868, Geology and paleontology: GS Ill., v. 3, 574 p.
- WORTHEN, A. H., 1870, Geology and paleontology: GS Ill., v. 4, 508 p.
- WORTHEN, A. H., 1873, Geology and paleontology: GS Ill., v. 5, 619 p.
- WORTHEN, A. H., 1875, Geology and paleontology: GS Ill., v. 6, 532 p.
- WORTHEN, A. H., and JAMES SHAW, 1873, Geology of Rock Island County: GS Ill., v. 5, p. 217-234.

## Z

- ZANGERL, RAINER, and E. S. RICHARDSON, JR., 1963, Paleogeological history of two Pennsylvanian black shales: Fieldiana—Geol. Mem. 4, 352 p.



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